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Renewable Energy

Akshay Urja

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Renewable Energy
Akshay Urja

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AUGUST 2013

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(Published in English and Hindi)

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From the Editor's Desk

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Dear Readers,

Energy consumption is an indicator of a person's standard of living. Thus the higher per capita energy consumption of a country indicates a rich or poor country in energy as well as in financial terms. Today per capita electricity consumption of our country has reached about 750 kWh per year, which is fair progress in the last two decades. However, it is still low as compared to many countries in the world. There are mainly two factors responsible for low energy consumption. The first is the unavailability of required electricity in the rural sector coupled with insufficient transmission and distribution infrastructure. The second is the gap between overall demand and supply of electricity. Thus in many cases it becomes uneconomical to take the grid to thinly populated, remote areas.

In this scenario, the decentralized supply of electricity is a need of the day as also a viable solution. Recently the Central Electricity Authority (CEA) has notified the CEA (Technical standards for connectivity of the distributed generation resources) Regulations 2013 which enable small size power plants, including the plants generating power from solar, biomass, wind or other resources, to be connected to the grid. This will also provide a fillip to the grid connected solar photovoltaic (SPV) rooftop programme being implemented by the Ministry of New and Renewable Energy (MNRE). Decentralized, hybrid power plants need to be setup in the country to meet the electricity requirement at the local level. More efforts are required to popularise renewable energy applications based on decentralized power in the country.

I am happy to mention that with your kind support and overwhelming response 'Akshay Urja' has completed a journey of eight years. The current 51st issue has interesting information on geothermal energy, biomass, biofuel and fuel-cell technologies. I hope you find the content useful.

Please do send your comments and suggestions to make Akshay Urja a more informative and valuable magazine.

Happy reading.

अक्षय ऊर्जा से देश विकास

AKTripathi

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Letters to the Editor

I had the opportunity of picking up a copy of your magazine (June 2013) at the SCOPE Complex, New Delhi, which had interesting and useful information about developments in renewable energy — government initiatives, business models etc. We at Corporate HSSE of Bharat Petroleum are taking steps to study the various options of conserving and generating energy through renewable sources. I personally feel that your magazine will provide us immense help and guidance in this direction.

Atul Kumar
Sewree Fort Road,
Sewree (E), Mumbai.

I am working as an Assistant Professor in the department of mechanical engineering in Guwahati, Assam. I have taken up research in 'solar energy' recently. While looking for material I happened to read Akshay Urja and found it extremely useful for providing me a direction in my research.

Rajiv LB Roy
Asst. Professor, Dept. of MEA
University, Panikhaity,
Guwahati.

I am pursuing an M.Tech in renewable energy technology from Centre for Energy and Environment, RTU, Kota. Akshay Urja contains a lots of updated and innovative information about renewable energy technology. It helps me stay in touch with all the new findings on technology and research in the field of renewable energy.

Burhanuddin Bohra
Near Gadh Palace Tipta,
Kota, Rajasthan.

I read the newsletter, 'Akshay Urja', June 2013 issue that is subscribed by our department. The newsletter was found to be very useful and highly informative in the renewable energy sector.

T. Palaniappan,
Senior Manager (New Project)
NTPC Ltd., Chennai.

I regularly receive the 'Akshay Urja' magazine, in both versions—Hindi and English, at my Pune address. I am thankful to you for sending me such an informative and useful newsletter which contains latest information on inventions, government programmes and emerging paradigms in the renewable energy sector. It is indeed a need of the hour.

Yashwant Shivram Chopade,
Kaspate, Wakad,
Pune, Maharashtra

Akshay Urja gave me enough *urja* to congratulate you and your team for the good work. India has not used its resources adequately to invent good solar products. The sun gives ample opportunities to produce enough energy which will take care of our energy needs. I had no electricity in my house for 30 years and therefore I can understand the pain of the poor who do not have access to electricity to even meet the basic minimum requirement of lighting. Through the medium of 'Akshay Urja' you are promoting the cause of renewable energy and that is really commendable.

Sandesh V. Naik,
Bhatlem, Panaji,
Goa

'अक्षय ऊर्जा' के माध्यम से मैं आपको यह पत्र बस्तर जिले से लिख रहा हूँ। मैं आपकी संस्था में काम करना चाहता हूँ और मैं आदिवासी क्षेत्रों में ऊर्जा प्राप्त करने के तौर–तरीकों के बारे में भी अध्ययन करना चाहता हूँ। इस हेतु मुझे अवसर प्रदान करने की महति कृपा करें।

संजय कुमार पांडेय
हिकमीपारा, जिला बस्तर
छत्तीसगढ़

आपकी यह पत्रिका 'अक्षय ऊर्जा' हमें हमेशा मिलती रहे, इसकी व्यवस्था कराने का कष्ट करें क्योंकि सन् 2005 के बाद पत्रिका के माध्यम से मुझे अक्षय ऊर्जा के बारे में अनेक जानकारियाँ प्राप्त हुई हैं। पत्रिका काफी अच्छी और उपयोगी है। अक्षय ऊर्जा के क्षेत्र में देश–विदेश में क्या प्रगति चल रही है, यह भी जानकारी मिलती है। 'अक्षय ऊर्जा' द्वारा ज्ञान वर्धन एवं लोगों की व्यक्तिगत् एवं सामाजिक ऊर्जा की अवश्यकता पूर्ति कैसे हो, यह भी इसके माध्यम से समझा जा सकता है।

राजेश कुमार त्रिपाठी
जवाहरनगर, जिला–सतना
मध्य प्रदेश

P 34270

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja will make every effort to make this newsletter highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in terms of content and presentation. **Editor: Akshay Urja**

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Solar passive design, University of Agriculture and Forestry, Solan, Himachal Pradesh

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India has a huge potential to become a leading contributor in generating eco-friendly and cost effective geothermal power.

Algae farming in less than 2-3 per cent of India's total land would make the country self sufficient in liquid fuel.

A fuel cell power plant creates very less pollution compared to the pollution caused by conventional combustion generating systems.

RENEWABLE ENERGY NEWS

MNRE SANCTIONS 20,000 SOLAR LANTERNS FOR FLOOD AFFECTED PEOPLE OF UTTARAKHAND

The Ministry of New and Renewable Energy (MNRE) has sanctioned central financial assistance of Rs. 4.4 crores for the distribution of 20,000 solar lanterns to the people in the flood affected areas of Uttarakhand. The Ministry will be meeting the full cost of solar lanterns to be distributed. Each lantern costs approximately Rs. 2200. This project will be implemented by the Uttarakhand Renewable Energy Development Agency, Dehradun. Immediately after the calamity that struck the Himalayan State on June 15, 2013, Union Minister for MNRE, Dr. Farooq Abdullah instructed his Ministry to enquire from the Government of Uttarakhand about the ways in which the Ministry could help the affected people. The Ministry, in turn, upon receiving a request from the Government of Uttarakhand for providing solar lanterns issued its in-principle approval for the same, immediately. These solar lanterns would provide lights in the far-flung and badly affected areas which have been totally cut-off from the grid and where the extension/repair of grid lines would take several months. These would help the villagers to not only complete their normal works after dusk but also keep off wild animals from their habitat. The Ministry has been meeting 100 per cent funding for distribution of solar lanterns to the natural calamity/disaster affected people in different parts of the country. The Ministry had earlier provided for the full cost for 14000 solar lanterns for Aila affected people in West Bengal during 2009-10; 1000 solar lanterns in Leh during 2010-11 to the people of flash flood affected areas and 14,900 solar lanterns in Sikkim during 2011-12 to the earthquake affected people.

PIB, July 08, 2013

3 MILLION USD LOAN TO CONSTRUCT A ROOFTOP SOLAR PROJECT IN GUJARAT

IFC, a member of the World Bank Group, is providing a 3-million USD loan to independent energy producer Azure Power. The loan is for one of Azure Power's subsidiaries to construct a rooftop solar project in Gujarat. This would

expand access to clean energy and create economic opportunities for local residents. This is the country's first rooftop solar project based on a public-private partnership model in India. The Gujarat Government awarded the project through competitive bidding for a period of 25 years. To implement the project, Azure Power is constructing a 2.5-megawatt rooftop solar project in Gandhinagar, which will be connected to the State electricity grid. IFC's investment in the subsidiary is expected to help avoid around 3,600 tonnes of carbon emissions a year. The project is a role model for rooftop generation of solar power across states. IFC's investment in the project demonstrates the viability of distributed solar power generation in India. Azure Power is an existing client of IFC and has a current portfolio of about 55 MW of solar power projects in India. The state government will be facilitating WSPPL with the necessary approvals, permission, land acquisition, registration and clearances for the project. Welspun Energy expects to soon be signing the agreement with Punjab State Power Corporation Ltd. (PSPCL).

The Hindu, July 11, 2013

NTPC SETTING UP SOLAR PLANT NEAR FARIDABAD

NTPC
5 मेगावाट सौर ऊर्जा परियोजना
जाजरू, फरीदाबाद
भूमि पूजन एवं शिलान्यास समारोह
मुख्य अतिथि: श्री अनिल कुमार झा, निदेशक (तकनीकी)
दिनांक 09 जुलाई, 2013
5 मेगावाट सौर ऊर्जा
श्री अनिल कुमार झा

NTPC, on July 9, 2013 laid the foundation stone of a 5 MW solar photo-voltaic plant at Village Jhajru near NTPC Faridabad. The project is being constructed on approximately 20 acres of land. The work for this project has been awarded to Eversun Energy Pvt. Ltd. and Enmas GB Power System Projects Ltd for main solar plant package and power evacuation package, respectively. This plant will generate 7.437 million units of electricity annually. This electricity will be equivalent to the power requirement of approximately 6,000 households. With zero pollution, this plant will contribute to about 6,800 tonne reduction in CO_2 generation. NTPC is venturing into renewable energy with an objective to broad base generation mix by evaluating conventional and alternate sources of energy to ensure long run competitiveness and mitigate fuel risks. In this endeavour, NTPC has already commissioned two 5 MW Solar PV projects each at Dadri and Port Blair. Further, presently 85 MW Solar PV projects are under implementation.

The Times of India, July 09, 2013

INDIA OFFERS PARTNERSHIP IN RENEWABLE ENERGY TO MONGOLIA

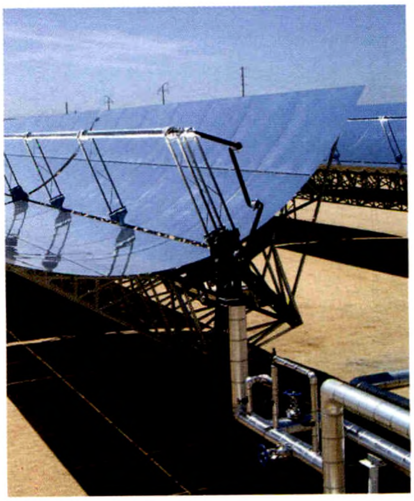
India has offered to cooperate with Mongolia in developing its renewable energy sector as well as in human resources development.

The offer was made by Minister for New and Renewable Energy Dr. Farooq Abdullah to President Tsakhia Elbegdorj of Mongolia at Ulaanbaatar.

Dr. Abdullah is in Ulaanbaatar to represent India at the inaugural ceremony of the President of Mongolia, Tsakhia Elbegdorj, who has been re-elected to a second four year term.

The oath taking ceremony was attended by members of Mongolia's Parliament and Government as well as representatives from several countries, including ministerial level-delegations from Russia, China and France.

India and Mongolia have close and warm ties underpinned by civilisational and cultural linkages with this predominantly Buddhist nation. A large number of Mongolians travel to India for spiritual, educational and medical



purposes. Indian cuisine and cinema are becoming increasingly popular in this landlocked nation of 3 million people.

Bilateral relations have expanded during the past few years to cover cooperation in defence and strategic issues. President Elbegdorj had chosen India as his first overseas destination after taking over as President of Mongolia for his first term in 2009.

The government's decision to depute a senior Cabinet Minister to the inauguration underlines the importance that India places on further strengthening its bilateral relations with Mongolia.

Business Standard, July 18, 2013

ASSESSMENT OF SOLAR ENERGY POTENTIAL

The Government has initiated a comprehensive programme to augment solar radiation resource assessment in the country including Ladakh area. In Phase-I of this programme, one Solar Radiation Monitoring Station has been established at Leh through Centre for Wind Energy Technology, Chennai. The data from various stations is transmitted to a central server maintained at C-WET and is made available to various stakeholders after carrying out quality checks. As per data recorded through one of such stations, the peak value of solar radiation at Leh reaches up to seven kilowatt hour per day per square metre of area which is quite high as compared to other locations in the country. However, no assessment of the potential of grid fed solar energy in Ladakh area has been carried out taking into account availability of land area.

As indicated by solar radiation data available for various parts of the country, several States, especially the Western States viz. Gujarat, Rajasthan, Maharashtra and Andhra Pradesh, and some parts of Tamil Nadu, Karnataka, Madhya Pradesh, have very good potential of setting up grid connected solar power projects in the country. However, a comprehensive survey of land for setting up of solar projects has not been carried out in any state.

PIB, August 20, 2013

SUBSIDY FOR SOLAR ENERGY UNITS

No subsidy is given by the Government on the capital investment for setting up grid-connected solar power plants. These are installed on build-own-operate basis, and the solar project developer is paid a feed-in tariff for the power injected into the grid. However, under the Rooftop Photovoltaic and Small Solar Power Generation Programme (RPSSPGP) which was a one time 100 MW scheme, a generation based incentive was provided. Under the Off-grid and Decentralized Solar Applications scheme of Jawaharlal Nehru National Solar Mission (JNNSM), Rs 399.18 crores were released by the Ministry during 2012-13 for sanction and installation of Off-grid SPV power plants and systems in the country.

The Ministry, under the Off-grid and Decentralized Solar Applications scheme of Jawaharlal Nehru National Solar Mission (JNNSM) provides a subsidy of 30 percent of the project cost for off-grid SPV power plants having module capacity upto 100 kWp depending on their capacity and configuration in general category States. In Special Category States, UT Islands and districts with international borders, the Ministry provides 90 percent of the cost of the off-grid SPV power for installation by Central and State Government Ministries, Departments and their organizations, State Nodal Agencies and Local Bodies.

State Nodal Agencies submit the projects in their respective State to the Ministry for availing the central financial assistance for installation of off-grid solar PV systems/power plants. The Ministry sanctions the project proposals which are found complete in all respect as per the guidelines of the programme and availability of funds.

PIB, August 5, 2013

TECHNOLOGIES FOR NEW AND RENEWABLE ENERGY

The Ministry of New and Renewable Energy has issued comprehensive policy and guidelines for supporting research, design, development, demonstration and manufacture. The Ministry provides support to academic and research institutions including autonomous bodies and industry for research, development and demonstration on cutting edge new and renewable energy technologies including hydrogen, fuel cells and alternative fuels for surface transportation. Financial assistance for the projects that involve industry is normally restricted to 50 percent of the project cost whereas it can be upto 100 percent of the cost of projects for academic institutions, government/non-profit research organisations and NGOs. Some of the projects under implementation in the cutting edge technologies include production of hydrogen by splitting of water, through fermentation of biological wastes, gasification of biomass, and reformation of biomass derived glycerol; storage of hydrogen in hydrides and carbon materials, development and demonstration of engines/vehicles for use of hydrogen and hydrogen blended fuels; development of fuel cells including materials and components; and different aspects of biofuels.

PIB, August 5, 2013

ITC POWERS ITSELF WITH WIND CLUSTERS

FMCG major ITC Ltd is powering itself up with wind farm clusters. As it expands its wind power generation capacity, ITC gradually reduces its dependence on fossil fuels. Renewable energy contributes to over 41 per cent of the company's total power consumption. This is poised to go up to over 50 per cent as it sets up more projects.

The company has installed wind farms with over 70 MW at sites close to its facilities and is in the process of setting up 63 MW more. Significantly, last financial year, it also brought down overall power consumption across all its business divisions. This is part of the corporate wide sustainability drive.

The new capacity includes a 46 MW farm at its Paper unit at Bhadrachalam in Andhra Pradesh. The company has recently awarded the supply contract to Gamesa India, part of the Spanish wind energy equipment supplier.

Sanjib Bezbaroa, Head of Corporate Environment, Health and Safety, told Business Line ITC has adopted a low carbon growth path to address environmental challenges such as global warming, climate change and depletion of natural resources.

The setting up of renewable energy sources also addresses the objective of reducing dependence on external source for power generation. Most States in South have demand supply gap. "The contribution from renewable energy to the overall energy consumption of ITC is about 41 per cent. We plan to take this to over 50 per cent within three years," he said.

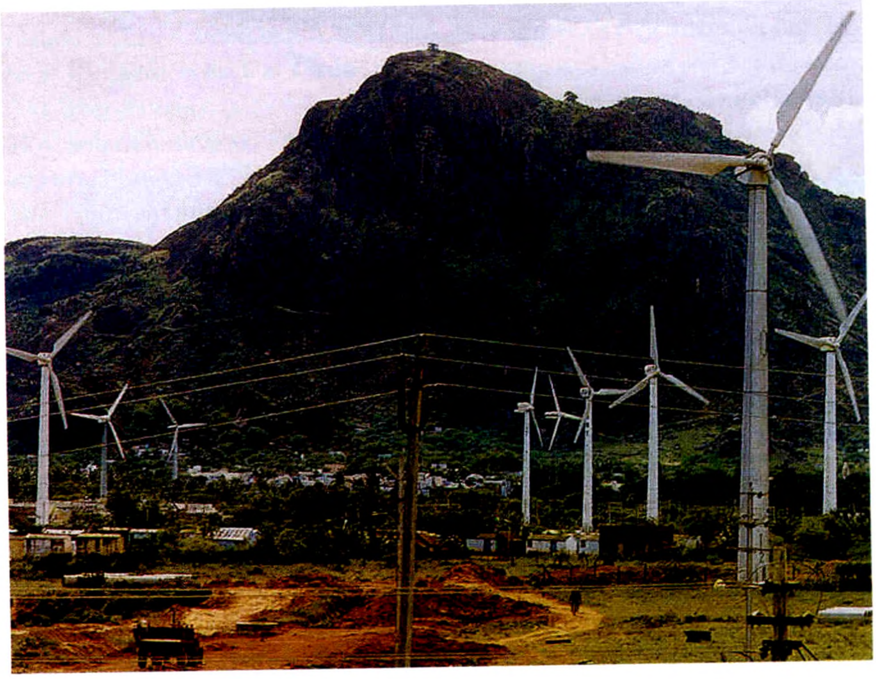
The company has commissioned a study of potential to generate additional power through renewable energy sources. "We expect this process to be completed soon. Merely having a potential at one site will not be sufficient, it has to suit the company's requirements," he explained.

"The other thing about renewable energy source is it cannot fully meet the requirement of large manufacturing units. Therefore, the setting up of new units factors various issues," he said.

The 32-acre Infotech Park in Bangalore is fully powered by renewable energy, some of the hospitality projects, including ITC Grand Chola, and paper units in Coimbatore, Kovai and printing and packaging unit at Chennai are all supported, some fully powered by wind farms. It is investing in wind farms to fully power the new plant at Mysore.

The company has invested over Rs 400 crore and expects to commit similar amount in setting up more renewable energy projects in the country, sources indicated.

The Hindu, July 10, 2013



SWANSEA BAY HYDROKINETIC PROJECT CONTINUES MOVING FORWARD IN SOUTH WALES

Energy development group Tidal Lagoon Power (TLP) Limited has reached a significant milestone in the development of a massive hydroelectric power project with the announcement of three design, build and deliver agreements.

HydroWorld.com reported in November 2012 that TLP Limited would likely receive private financing for the project from Atkins Engineering, Van Oord and Costain Infrastructure, among others, though the three have now been named for the project's actual development phase as well.

According to TLP, the US$966.5 million project will consist of a 6-mile-long, 35-foot-high semi-circular sea wall that will enclose an area west of Swansea Marina. The wall would be dotted along its length with a number of hydro turbines, giving the project a cumulative capacity of around 250 MW.

Each of TLP's three partners adds a unique quality to the project's development, the company said.

The Swansea is the first tidal lagoon power project envisioned by TLP, which said in May that it is considering a similar project off Wales' north coast. As much as 10,000 MW of tidal lagoon power potential in the United Kingdom, the group said. Should permitting progress as hoped, TLP said the Swansea project could be connected to the Welsh grid in 2017.

renewableenergyworld.com, July 10, 2013

RENEWABLE ENERGY DEVELOPERS BUYS 18.5 MW ONTARIO WIND PROJECT

Renewable Energy Developers, a Canadian project-focused clean power firm, will buy the Grey Highlands Clean Energy wind project in Ontario under a binding agreement with Natenco.

The 18.5MW project is located in Grey County and has a 20-year power purchase agreement with the Ontario Power Authority.

The pair has entered into a letter of intent, and the transaction will be subject to standard conditions, including receipt of any consents required from the OPA and other third parties, and settlement of definitive agreements.

The company has actively participated in development of the project since January 2013 and will be providing additional development funding prior to closing.

A statement by Renewable Energy Developers said that going forward it would look to complete the acquisition with a financial partner.

New Energy World Network, July 16, 2013

CHINA CONFIRMS GOAL FOR 35 GW OF SOLAR CAPACITY BY 2015

China, the world's biggest maker of solar panels, plans to increase fivefold its installed solar capacity to more than 35 gigawatts by 2015 to support an industry faced with declining profits, slowing exports and a supply glut.

The nation will add 10 gigawatts of solar-power capacity annually over the next three years, according to a statement from the State Council posted on the central government's website today.

The move will help reduce the industry's reliance on exports and ease oversupply that contributed to a 20 percent plunge in the average price of solar panels last year, according to data compiled by Bloomberg.

Risen Energy Co. jumped 10 percent, its daily limit and the most since Feb. 18, to 6.71 yuan in Shenzhen trading. Hareon Solar Technology Co. rose as much as 6.8 percent and traded 4.6 per cent higher to 6.49 yuan as of 1:25 p.m. in Shanghai.

"While the Chinese government is determined to boost the domestic market, it is not sufficient to eliminate oversupply," said Wang Xiaoting, a Beijing-based analyst at

Bloomberg New Energy Finance. "Panel prices will stay stable in 2013."

China will also offer tax breaks to solar companies that acquire others, merge or reorganize their operations, the State Council said. The government encouraged makers of polysilicon, the raw material used to make solar panels, to form partnerships or combine with "advanced chemical enterprises."

renewableenergyworld.com, July 15, 2013

THAILAND PLANS TO BOOST RENEWABLE ENERGY OUTPUT TO 25 PER CENT OF TOTAL

Thailand plans to increase production of electricity from renewable sources to 25 percent of total output over the next 10 years to reduce imports and boost energy security, the Ministry of Energy said.

Power generation from renewables will jump by 51 per cent to 13,927 megawatts by 2021, from a current target of 9,201 megawatts, the ministry said in a statement on July 16, 2013.Under the new goal, approved by the National Energy Policy Committee, output from biomass will be 4,800 megawatts; biogas 3,600 megawatts; solar 3,000 megawatts; wind 1,800 megawatts and the balance will come from hydropower and waste, it said.

Thailand is providing incentives for renewable energy projects to reduce its reliance on fossil fuels, which account for more than 80 percent of the nation's energy consumption, the U.S. Energy Information Administration said on its website.

Bloomberg, July 17, 2013

DOE LAUNCHES GEOTHERMAL REGULATORY ROADMAP

In hopes of reducing one of the more costly and time consuming steps in geothermal project development, the U.S. Department of Energy issued its Geothermal Regulatory Roadmap to "help developers navigate regulatory requirements at every level of government." The DOE charged the National Renewable Energy Laboratory with the task of rounding up key industry representatives and federal, state and local officials to pinpoint areas where development may be streamlined.

In 2011, a DOE report identified permitting as one of the largest barriers to geothermal development. According to industry experts, a geothermal project typically takes seven to eight years to complete, and four of those years are bogged down with permitting red tape. At a recent conference, Karl Gawell of the Geothermal Energy Association called for the industry to come together and deal with the issue.

The roadmap includes clear-cut flowcharts with instructions for each step of the development process, whether a project is in the siting phase or drilling phase, and links to necessary documents and forms. The roadmap is currently available for eight geothermal-heavy states: Alaska, California, Hawaii, Idaho, Montana, Nevada, Oregon, and Utah, with Colorado and Texas next in line. DOE hopes the roadmap will help lower development costs and reduce financial risks.

renewableenergyworld.com, July 15, 2013

SOLAR HEADPHONES THAT CHARGE MOBILES

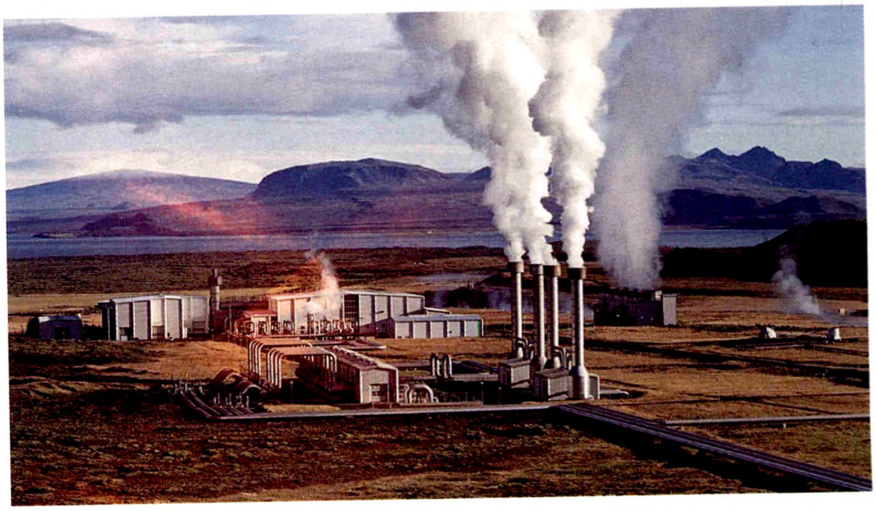
A pair of headphones that can harness solar power to charge mobile devices when you are on the move has been designed in the UK.

Andrew Anderson, a Glasgow-based designer, launched the OnBeat headphones on crowdfunding site Kickstarter and hopes to have them on sale by early next year.

The headphone band is fitted with a flexible solar cell with a charge capacity of 0.55 watts.

"The headphones have an integrated flexible solar cell that covers the full headband which capture solar energy whilst out and about," Anderson said.

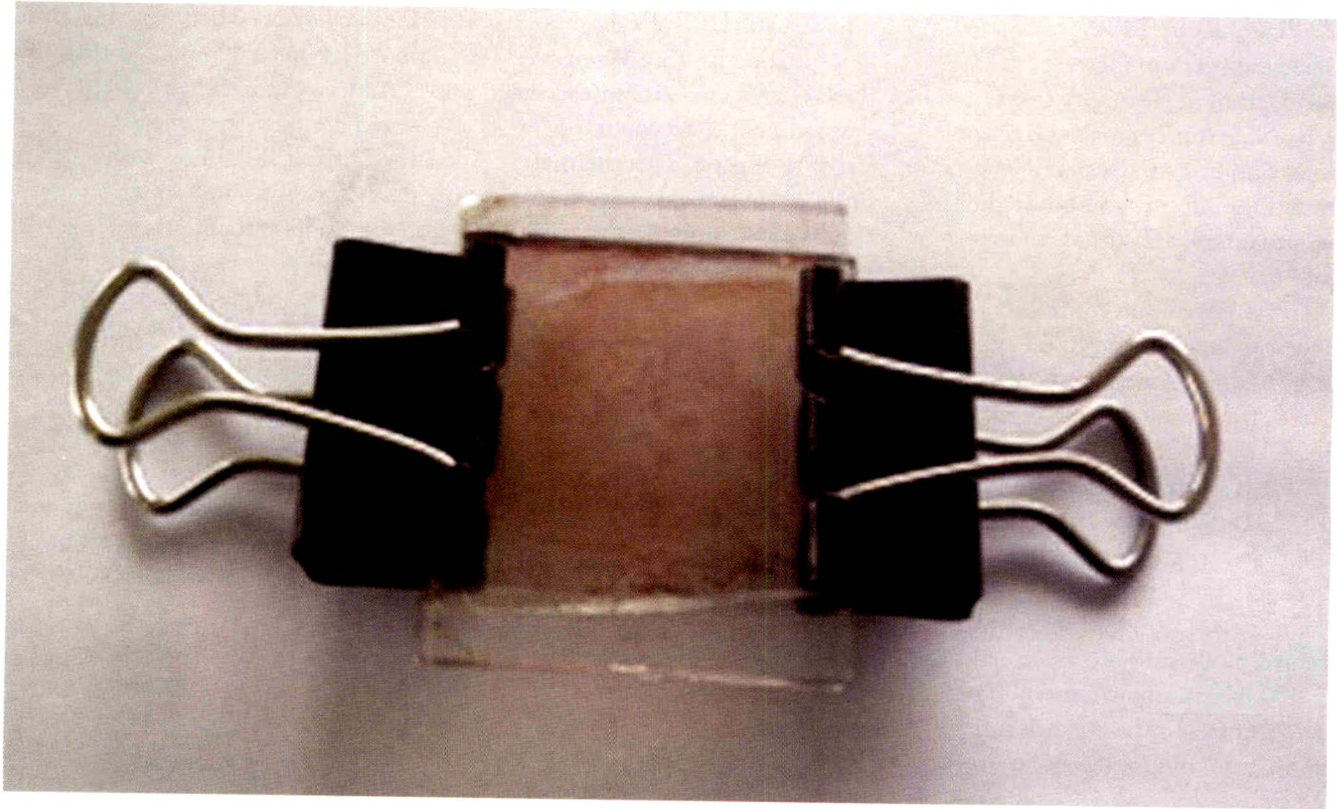
Press Trust of India, July 10, 2013



RECENT DEVELOPMENT IN DYE-SENSITIZED SOLAR CELLS

Dye-sensitized solar cells (DSSCs) are emerging as third generation photovoltaic (PV) device, due to their low production cost and high conversion efficiency. This review describes recent developments in dye-sensitized solar cell research with a focus on development of material and method.

SWAPNA OJAH, RANJITH G. NAIR AND S. K. SAMDARSHI



Dye-sensitized solar cell

The concept of DSSC was first presented in 1991 by Michael Grätzel and Brian O'Regan. Grätzel won the Millennium Technology Prize in 2010 for his work in the area of DSSCs. The DSSC is a photoelectron chemical device. Generally, a dye-sensitized solar cell consists of three main components: a dye coated nanocrystalline TiO_2 layer on a transparent conductive glass substrate, an iodide/triiodide redox couple in an organic solvent as an electrolyte, and a platinum film having high electrocatalytic activity coated on conductive glass as counter electrode; its operation is similar to that of photosynthesis. The operation of DSSC can be explained in three steps: first the dye molecule absorbs the photon and gets excited. The excited dye molecule is then given off to the conduction band of semiconductor and it gets oxidized. After that the transparent conducting oxide (TCO) layer collects the excited electron from the conduction band and the electrons flow from the external load to the counter electrode. Finally the oxidized dye molecule is reduced by gaining electrons from the electrolyte solution (Fig 1). DSSC is the only device that absorbs photon and converts them to electric charge without the need of intermolecular transport of electronic excitation. In conventional solar cells both light absorption and charge carrier transport were performed simultaneously, whereas in DSSC the two operations are performed separately. An energy conversion efficiency of more than 11 per cent has been achieved in DSSCs with an organic liquid-based electrolyte containing I_3-/I- as a redox couple.

PLANTS AND BACTERIA USE PORPHYRIN BASED CHROMOPHORES FOR CONVERTING SOLAR ENERGY INTO CHEMICAL ENERGY.

PRESENT DSSC RESEARCH AND DEVELOPMENT

Dye: The dye absorbs the photon and creates an electron—it allows the electron to be injected into the conduction band of the semiconductor. There are two classes of dyes: organometallic and organic dyes. Organometallic dyes contain a transition metal in the structure while organic dyes can be indoline-derived dyes, porphyrin-based complexes, benzothiazole merocyanine based dyes, oligoene dyes, and coumarin derivatives. Currently the most efficient DSSCs are ruthenium-based sensitizers such as N3, N719, Z907 and black dye, which have achieved remarkable power conversion efficiency of 10-11 per cent under standard global air mass 1.5 (AM 1.5) illumination. However, disadvantages such as rarity, high cost, relatively low extinction coefficient, hard to be purified and environmental pollution restrict its large scale production. Also Ru dyes do not absorb in the infrared region except black dyes that absorb light up to a wavelength of 900 nm but is very expensive and produces lower VOC due to recombination problems. This has led to the search for cheaper and safer organic based dyes. Organic dyes have many advantages over Ru based dye such as large molar extinction coefficient, control of absorption wavelength, facile design and synthesis and lower cost than Ru complex. Though a dye sensitized electrolyte (DSE) using organic dye does not give high conversion efficiency, it allows the making of thinner DSE.

Plants and bacteria use porphyrin based chromophores for converting solar energy into chemical energy. Campbell *et. al.* synthesized a novel green porphyrin sensitizer in which the aryl group acts as an electron donor and malonic acid binding group as an acceptor; this gives conversion efficiency upto 7.1 per cent under illumination AM 1.5.

Hwang *et. al.* synthesized an organic dye TA-St-CA which contains a p-conjugated oligo-phenylenevinylene unit with an electron donor–acceptor moiety for intramolecular charge transfer and a carboxyl group as an anchoring unit for the attachment of the dye onto TiO_2 nanoparticles, and found that the solar energy conversion efficiency is 9.1 per cent at 1.5 AM illumination. Under same conditions the efficiency of N719 was 10.1 per cent.

Mater *et. al.* synthesized a new ruthenium polypyridyl dye TG6, and compared it with N719 dye and found that solar to electricity conversion efficiency is 0.2 per cent higher than N719 DSSC with 12µ m thick TiO_2 film and EL01 as electrolyte at a slightly higher voltage. The efficient performance of TG6 dye is attributed to the high absorption extinction coefficient and extended absorption in the visible region of the solar spectrum.

Lin *et. al.* designed and synthesized two new organic sensitizers (TPCADTS and TP6CADTS) containing coplanar diphenyl-substituted dithienosilole as the central linkage for high-performance dye-sensitized solar cells. By incorporating the diphenyl-substituted dithienosilole (DTS) core, these two dyes exhibited enhanced light-

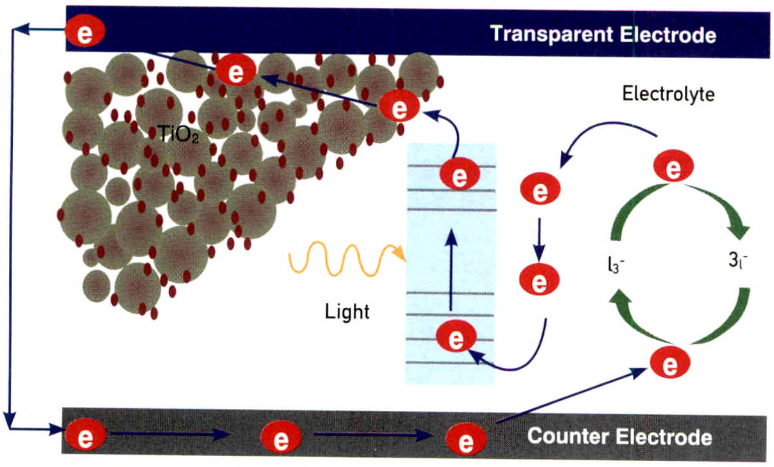


FIG 1: The working of a dye-sensitized solar cell

capturing abilities and suppressed dye aggregation. These two dyes were used as the organic sensitizers in DSSCs and it was found that solar-cells based on the sensitizer TPCADTS and TP6CADTS yielded a overall conversion efficiency up to 6.65 and 7.6 per cent, reaching about 80 and about 96 per cent respectively of the ruthenium dye N719-based reference cell under the same conditions.

Working electrode: The working electrode absorbs dye molecules and conducts photoelectrons. Generally semiconductors with wide band gap like TiO_2, SnO_2, ZnO, $NbO_5$and $SrTiO_3$ are used as a photoanode. The desirable properties of the working electrode are large surface area to absorb large amounts of dye and high electron diffusion to assure its conduction to the conductive substrate before recombination.

Usually pure TiO_2 is used as the electrode which is oxygen deficient; this oxygen deficiency can create electron hole pairs. The oxidizing holes can either react with the dye and destroy it or are scavenged by iodide ions, thus reducing the lifetime of the dye-sensitized solar cell. To solve these problems, Ma *et. al.* introduced nitrogen-doped titania into the DSSC system to enhance the internal photonic conversion efficiency (IPCE) and to stabilize the solar cell by replacing oxygen deficient titania by visible-light-active, nitrogen-doped titania. An overall conversion efficiency of 8 per cent has been achieved.

For commercial production of DSE the use of TCO layer is not suitable because the cost increases significantly, therefore Park *et. al.* fabricated a new Ti-mesh electrode for high-efficiency, low-cost solar cell application that replaces the TCO. Thus the cell structure is composed of a glass/dye sensitized TiO_2 layer/Ti-mesh electrode/electrolyte/ metal counter electrode.

To suppress the recombination and improve the transport of photogenerated electrons across the TiO_2 nanoparticle network, Yang *et. al.* incorporated 2D graphene into the TiO_2 nanostructure photoanode to form graphene bridges in DSSCs and found that graphene can enhance the charge transport rate to prevent charge recombination and increase light collection efficiency, so that the total conversion efficiency was increased by 39 per cent, compared to the nanocrystalline titanium dioxide photoanode.

Lee *et. al.* reported that the charge recombination from TCO to electrolyte can be reduced when Nb-doped TiO_2 (NTO) is deposited on a FTO substrate, and the resulting NTO/FTO is used in DSSC as an electrode. The NTO compact layer also reduced the interfacial resistance and enhanced the PV conversion efficiency by 21.2 per cent compared to bare FTO based DSSE.

Counter electrode: Usually, a thin layer of platinum (Pt) catalyst deposited on transparent conductive oxide substrates is employed as a counter-electrode in DSSCs. Since Pt is expensive, rare and widely in demand as a catalyst in various chemical and electrochemical fields, many researches are looking to find an alternative to replace Pt. Cha *et. al.* reported Pt-free transparent counter electrodes for DSSC, which are fabricated using carbon nano-tube (CNT) micro-balls with dense CNT packing. When the transparency of a CNT micro-ball transparent counter electrode is more than 70 per cent, the energy conversion efficiency of its DSSC is 80 per cent more than the one prepared using a counter electrode consisting of Pt nanoparticles.Ramasamy *et. al.* reported highly efficient liquid and quasi-solid DSSCs based on large-pore sized mesoporous carbon counter-electrodes. In combination with dye sensitized TiO_2 working electrode, liquid and quasisolid DSSCs show 8.18 and 3.61 per cent, respectively, energy conversion efficiency under one sun condition. Wei *et. al.* reported a new type of counter electrode that consisted of substrate, aluminium film and catalyzed platinum film. This new counter electrode has many advantages over a Pt counter electrode - simple preparation, low cost, low resistance, high reflectance and so on. This improves the photoelectric conversion efficiency from 3.46 to 7.07 per cent.

IN THE CONVENTIONAL SOLAR CELL BOTH LIGHT ABSORPTION AND CHARGE CARRIER TRANSPORT WERE PERFORMED SIMULTANEOUSLY, WHEREAS IN DSC THE TWO OPERATIONS ARE PERFORMED SEPARATELY.

Electrolyte: The electrolyte reduces oxidized dye and transport holes in the cell. The conventional solvents used in DSC's electrolyte are some organic solvents such as c-butyrolactone, acetonitrile and 3-methoxypropionitrile. However, all of them are normally poisonous and volatile, which limits the DSSC industrialization. The air and water stable room-temperature ionic liquids (RTILs) are attractive due to their characteristics such as chemical and thermal stability, negligible vapour pressure, no flammability, high ionic conductivity and a wide electrochemical window. Though liquid electrolyte has achieved high efficiency, there are some disadvantages such as evaporation of electrolyte, health hazards, temperature stability problems, sealing problem etc. Generally, ionic liquids based on imidazolium salts are widely used as solvents for DSSCs. But, pure imidazolium iodide/triiodide room temperature ionic liquids are too viscous and obstruct the diffusion of the redox couple (I-/I_3-) in the electrolyte, and hamper the device performance. To overcome these problems, many researches are looking to replace the liquid electrolytes with solid or quasi-solid-type charge transport materials.

Bhattacharya *et. al.* developed a new kind of low-viscosity ionic liquid (1-ethyl 3-methyl imidazolium thiocyanate) solid electrolyte i.e. an ionic liquid doped solid electrolyte (ILSE). Due to an improvement in the number of ionic charge carriers provided by the ILSE it showed better conductivity. The PV performance of the solar cells can be improved by the doping of ionic liquid.

Lan *et. al.* prepared gel electrolyte by using TiO_2 gel to solidify liquid electrolyte which contained an organic iodide salt N-methyl pyridine iodide as I- source. The energy conversion efficiency of light-to-electricity of 3.06 per cent was achieved under irradiation of 60 mW cm-2. Guo *et. al.* developed a new ionic liquid S-propyltetrahydrothiophenium iodide (T3I) as the solvent and iodide ion source in electrolyte for dye-sensitized solar cells. The photoelectric conversion efficiency of the cell is 3.51per cent under one sun (AM 1.5). Jhong *et. al.* synthesized eutectic mixture of glycerol and choline iodide (G.CI) as electrolyte for dye-sensitized solar cells. The energy conversion efficiency is found to be 3.88 per cent under AM 1.5, 100 mW/cm^2 illuminations.

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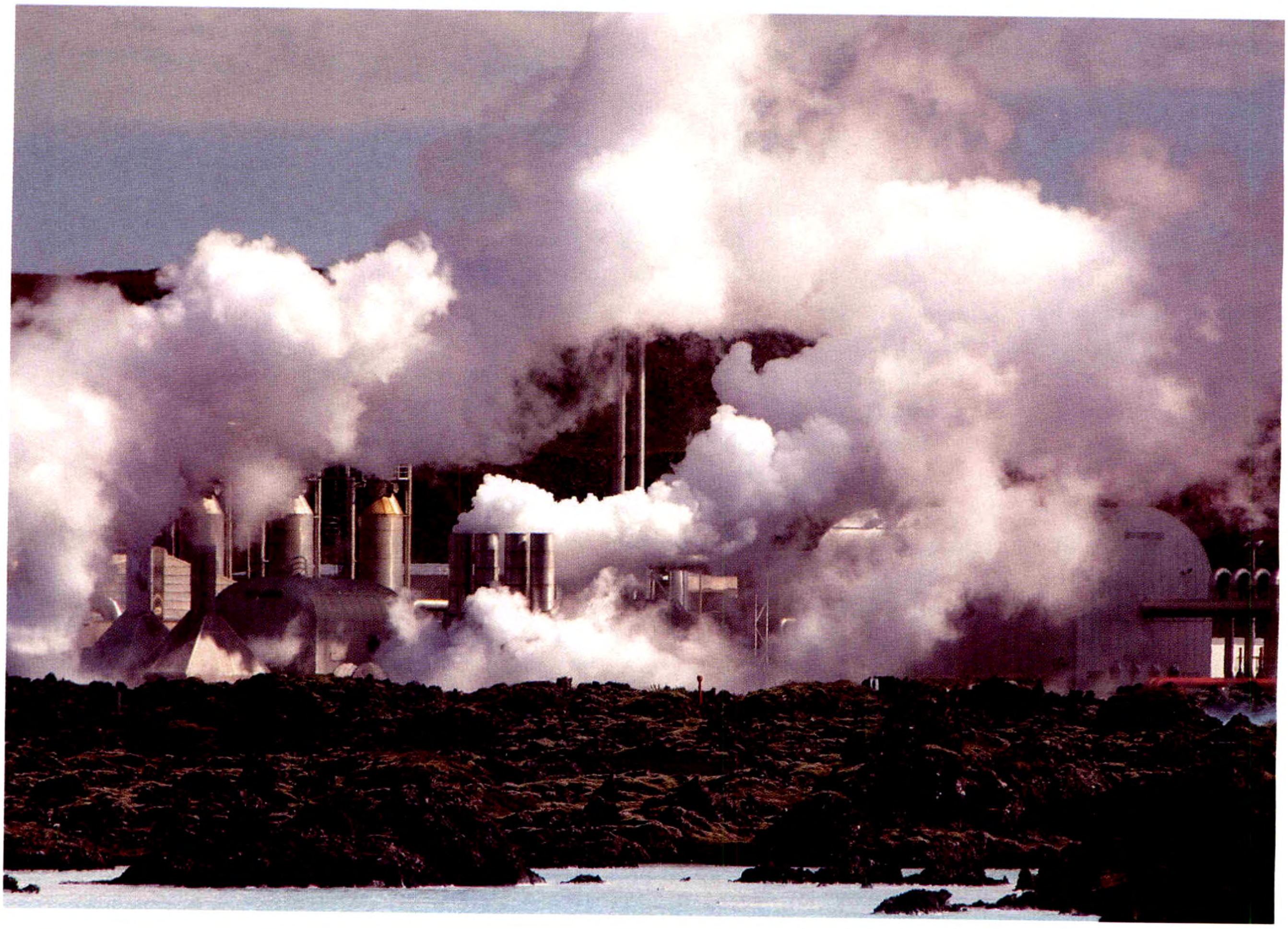
GEOTHERMAL ENERGY AND ITS POTENTIAL IN INDIA

Geothermal energy is one of the potential alternative energy sources catering to both industrial and domestic energy requirements in many parts of the world. Presently, it is being used as a source for producing electricity mainly along active plate boundaries.

OUM PRAKASH SHARMA AND POONAM TRIKHA



⮝ This geothermal power plant in Reykjavik, Iceland, is using its underground reservoirs of steam and hot water to generate electricity and to heat and cool buildings directly.

Energy is necessary for all activities in and around us. Energy provides comfort, increases productivity and allows us to live the way we want to. At present most of our energy demand is met by the energy obtained from conventional fossil fuels such as coal, petrol, diesel, natural gas, kerosene etc. It is estimated that we could run out of oil in about 40 years and of natural gas soon after. Not only are fossil fuels running out, but they're adding to our environmental problems by releasing harmful byproducts that increase pollution and contribute to global warming. In view of the limited store of fossil fuels and ever increasing gap between the demand and supply of energy, it is necessary to switch to new and renewable sources of energy. It is a fact that India has one of the highest potentials for effective use of renewable energy. During the last one decade, there has been a visible impact of renewable energy in the Indian energy scenario. Apart from contributing to about 12.5 per cent in the national electric installed capacity, renewable energy based applications have benefitted millions of people in the Indian villages by providing for their energy needs in an environment friendly manner. India is the world's fifth largest producer of wind power after Denmark, Germany, Spain, and the USA. Other renewable energy technologies, including solar photovoltaic (PV), solar thermal, small hydro power, geothermal, sea wave and biomass energy are also spreading. As greater reliance on renewable energy sources offers enormous economic, social, and environmental benefits, we need to explore more sources of renewable energy. Geothermal energy is one of the renewable sources of energy available in the form of vast natural reservoirs of heat energy in the earth's interior. A number of geothermal power plants, which generate more than 10,000 MW power are operational in at least 24 countries of the world. Besides, geothermal energy is being used directly for heating in at least 78 countries. The largest producer of this energy is USA that generates about 3,086 MW of electricity.

UNLIKE MOST POWER STATIONS, GEOTHERMAL POWER PLANTS DO NOT EMIT ANY POLLUTION AND GEOTHERMAL ENERGY CAN BE USED TO PRODUCE ELECTRICITY 24 HOURS A DAY.

WHAT IS GEOTHERMAL ENERGY?

Geothermal energy is one of the potential alternative sources of energy which has been successfully catering to both industrial and domestic energy requirements in many parts of the world over the last few decades. Geothermal is made of two Greek words – geo which means 'earth', and therme, which means 'heat'. Thus, geothermal energy is the heat from the earth. It is a clean and sustainable source of energy. Resources of geothermal energy range from the moderate-to-low temperature hot spring systems to hot rock found a few miles beneath the earth's surface, and down even deeper to the extremely high temperatures of molten rocks. Below the earth's crust, there is a layer of hot and molten rocks called magma. Heat is continually produced there, mostly from the decay of naturally radioactive materials such as uranium and potassium. Heat flows outward from the earth's interior. Normally, the crust of the earth insulates us from earth's interior heat. The mantle is semi-molten, the outer core is liquid and the inner core is solid. It is interesting to mention here that the amount of heat within 10,000 meters of earth's surface is 50,000 times more energy than all the oil and natural gas resources in the world.

In fact, geothermal energy is one of the oldest natural sources of heat and dates back to the Roman times, when the heat from the earth was used instead of fire to heat rooms and/or warm water for baths. Presently, it is being used as a source for producing electricity, mainly along plate margins.

HOW IS GEOTHERMAL ENERGY CAPTURED?

Now, the basic question is how do we use geothermal energy for the benefit of mankind? Normally geothermal energy is captured from geothermal hotspots. Basically, a hotspot is an area of reduced thickness in the mantle which allows the excess internal heat from the interior of the earth to flow to the outer crust. These hotspots include the volcanic islands, mineral deposits, and geysers normally known as hot springs. Following are some ways in which heat from these geothermal hotspots is obtained.

Hot Springs for Geothermal Power Plants: The most common way of capturing energy from geothermal heat is to tap into naturally occurring 'hydrothermal convection'

« Chhumathang hot spring located about 40 km north of Puga, Ladakh.

systems where cooler water seeping into earth's crust is heated up, and it then rises to the surface. When heated water from the hot springs is forced to the surface, it is a relatively simple matter to capture that steam and use it to drive electric generators. In order to set up geothermal power plants, holes are drilled into the rock to capture steam more effectively to drive electric generators. If the water comes out of the hot spring as steam, it can be used directly whereas the hot water can be used as a flash system.

Direct uses of Geothermal Heat: Geothermal reservoirs of hot water, which are found a couple of miles or more beneath the Earth's surface, can also be used to provide heat directly. This is called the direct use of geothermal energy. Direct use of geothermal energy is a very old method when people used hot springs for bathing, cooking food, and other day to day heating purposes. Besides, the hot spring water was used to heat greenhouses, fish farms and spas, to dry fish, de-ice roads, and improve oil recovery, and to heat. But now, modern systems are being used for direct-use in which a well is drilled into a geothermal reservoir to provide a steady stream of hot water. The water is brought up through the well and a mechanical system - piping, a heat exchanger, controls, which delivers the heat directly for its intended use.

Ground-source heat pumps: It is found that the temperature of the upper 10 feet of the earth is nearly constant - between 10°-16°C. During winter this region is warmer than the air above it, whereas in summer it is cooler. In order to take advantage of this resource, geothermal heat pumps can be set up to heat and cool buildings. Geothermal heat pump systems consist of a ground heat exchanger, a heat pump unit, and an air delivery system. The heat exchanger is basically a system of pipes called a loop, which is buried in the shallow ground near the building. Geothermal heat pumps use much less energy than conventional systems, since they draw heat from the ground. A much more conventional way to tap geothermal energy is by using geothermal pumps to provide heating and cooling to buildings.

Advantages and limitations of Geothermal Energy: Geothermal energy is used for heating homes and for generating electricity without producing any harmful emissions. The first advantage of using geothermal heat as a source of energy is that, unlike most power stations, a geothermal power plant does not create any pollution and geothermal energy can be used to produce electricity 24 hours a day. Thus, geothermal energy is an excellent source of clean, inexpensive and renewable energy. If the geothermal energy is harnessed correctly, it leads to no harmful by-products. Geothermal power plants are generally small and have little effect on the natural landscape, or the nearby environment. As no fuel is used to generate the power from the geothermal heat, running costs for geothermal power plants are very low. Moreover, the cost of the land to build a geothermal power plant, is usually less as compared to the cost of constructing an oil, gas, coal, or nuclear power plant.

Though geothermal energy has several advantages, it also has certain disadvantages and limitations. If harnessed incorrectly, geothermal energy can sometime produce pollutants. Improper drilling into the earth can release hazardous minerals and gases from deep down inside the earth, which can be contained quite easily. It is also feared that the geothermal power plant sites may run out of steam in the long run.

APART FROM CONTRIBUTING ABOUT 12.5 PER CENT IN THE NATIONAL ELECTRIC INSTALLED CAPACITY, RENEWABLE ENERGY BASED APPLICATIONS HAVE BENEFITTED MILLIONS OF PEOPLE IN INDIAN VILLAGES BY PROVIDING FOR THEIR ENERGY NEEDS IN AN ENVIRONMENT FRIENDLY MANNER.

PROSPECTS OF GEOTHERMAL ENERGY IN INDIA

India has huge potential to become a leading contributor in generating eco-friendly and cost effective geothermal power. Around 6.5 per cent of electricity generation in the world would be done with the help of geothermal energy and India would have to play a bigger role in the coming years in this direction. But, the power generation through geothermal resources is still in nascent stages in India. Geological Survey of India has identified about 340 geothermal hot springs in the country. Most of them are in the low surface temperature range from 37° C-90° C which is suitable for direct heat applications. These springs are grouped into seven geothermal provinces i.e. Himalayan (Puga, Chhumathang), Sahara Valley, Cambay Basin, Son-Narmada-Tapi (SONATA) lineament belt, West Coast, Godavari basin and Mahanadi basin. Some of the prominent geothermal resources include Puga Valley and Chhumathang in Jammu and Kashmir, Manikaran in Himachal Pradesh, Jalgaon in Maharashtra and Tapovan in Uttarakhand. A new location of geothermal power energy has also been found in Tattapani in Chhattisgarh. In addition, Gujarat is set to tap geothermal electricity through resources which are available in Cambay between Narmada and Tapi river.

Puga, which is located at a distance of about 180 km from Leh in the Ladakh region of Jammu and Kashmir across the great Himalayan range, is considered to be a good potential of geothermal energy. In Puga valley, hot spring temperatures vary from 30°C to 84°C (boiling point at Puga) and discharge up to 300 liters /minute. A total of 34 boreholes ranging in depths from 28.5 m to 384.7 m have been drilled in Puga valley. Thermal manifestations comes in the form of hot springs, hot pools, sulphur condensates, borax evaporates with an aerial extent of 4 km. The hottest thermal spring shows a temperature of 84°C and the maximum discharge from a single spring is 5 liters /second.

Chhumathang spring is another geothermal area located about 40 km north of Puga. The thermal water from Chhumathang is quite similar to the thermal waters at Puga except the difference that its water has relatively higher pH and sulphate. Geothermal activity at Manikaran occurs in the form of hot springs over a distance of about 1.25 km on the right bank of Parvati river with a temperature range of 34°C-96°C whereas on the left bank over a distance of about 450 m with a temperature range of 28°C-37°C. At Tapovan geothermal area, the highest temperature recorded is 65°C. The discharge

⌃India's first geothermal plant to come up in Chhattisgarh. NTPC has already started exploratory and preparatory work in this area. It has also started talks with Oil and Natural Gas Corp and international organisations for drilling operation.

from this spring varies between 0.83-9.2 litre/second. Similarly, Tattapani is a promising geothermal resource in Peninsular India. Thermal manifestation at Tattapani is very intense in an area of 0.05 sq. km with several hot spots, hot water pools and marshy land. The surface manifestations show occurrence of white to dirty white deposits identified as silica and moderate to low sag activity. Sixty thermal water springs occur at eighteen localities in the West Coast hot spring belt. One geothermal power project has a capacity of 25MW. Himurja, Himachal Pradesh has decided to select some geothermal resources in Beas valley, Parvati valley, Satluj valley and Spiti valley in Himachal Pradesh for deep drilling up to 2 km for exploitation of geothermal energy.

Obviously, geothermal energy has great potential as a clean, green and naturally occurring renewable source of energy. Geothermal hot water can be used for many applications that require heat including heating buildings, raising plants in greenhouses, drying crops, heating water at fish farms, and several industrial processes. It can be used for generating electricity as well. It is therefore necessary to explore the possibility of setting up more geothermal power plants to use the naturally occurring renewable source of energy. ✪

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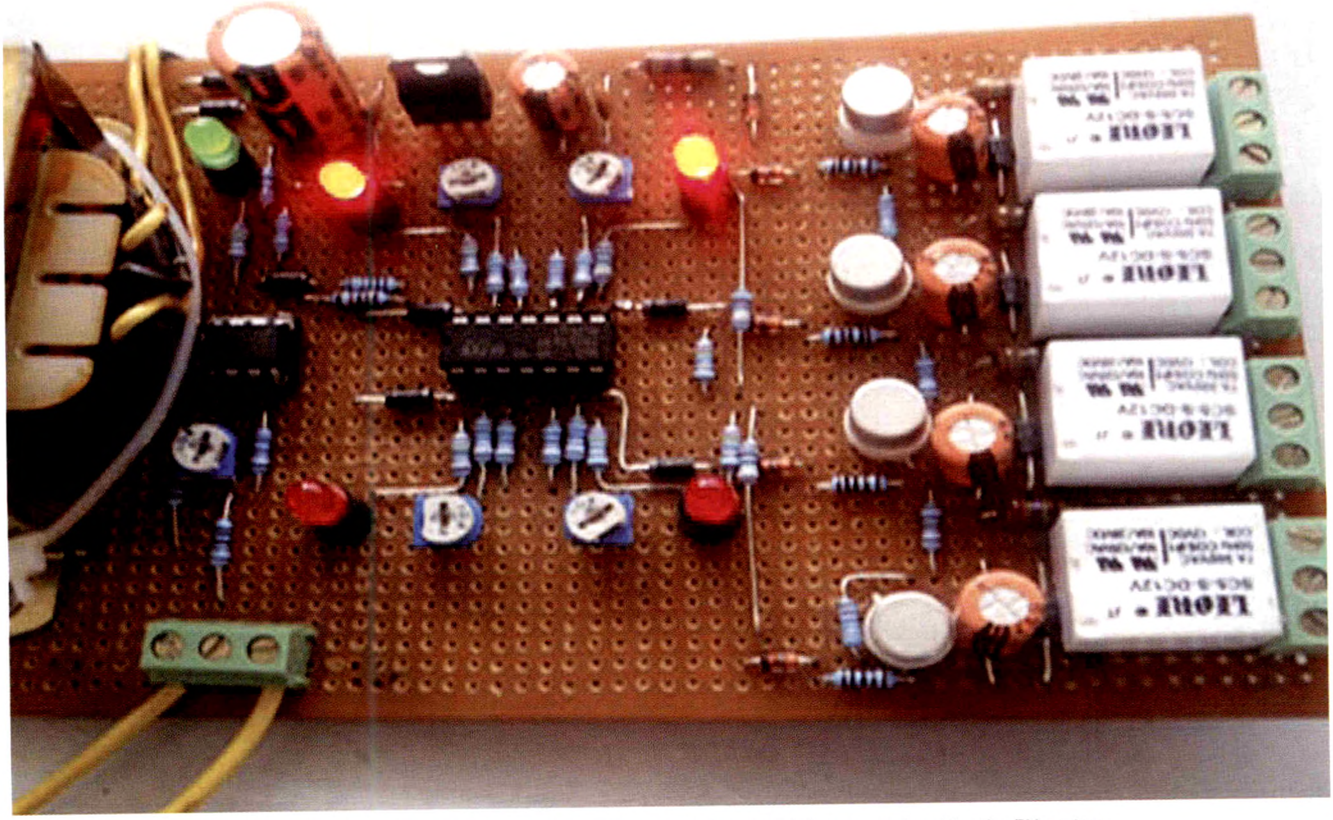


PV-modules connected in combinations of series and parallel configurations to get a higher power level for the PV system.

SOLUTION TO STOP BATTERY BANK DRAIN-UP

The paper presents an overview of battery bank drain-up issues for photovoltaic (PV) power plants at lower insolation for low and medium level (1 kW-50 kW) power plants, mainly intended for rooftop applications. The paper focuses on problems and challenges to stop the battery bank drain-up. This topology has many advantages as it is low in cost, volume and maintenance. In addition, it is often awarded higher priority than topologies with back-up inverters. Therefore the new concepts are important for future developments.

GANGA RAM POSANNAPETA

SOLUTION TO STOP BATTERY BANK DRAIN-UP

Renewable energy sources are making a more and more important contribution to the total energy consumed in the world. It is independent of limited fuels and has a very low impact on the environment. Today the contribution from photovoltaic (PV) energy compared to the other energy sources is very low, but due to decreasing system prices the market for PV systems is one of the most stable and fastest growing in the world. If this trend continues, PV will be one of the most important energy sources in the future. To maintain the further spread of PV systems, it is important to decrease the cost and make valuable improvements on the battery back-up PV-systems and at the same time improve the efficiency and reliability of these systems. In the part of improvements in the battery back-up system, the battery drain-up issue can be overcome by using simplest topology at very economical levels.

> THE MARKET FOR PV SYSTEMS IS ONE OF THE MOST STABLE AND FASTEST GROWING IN THE WORLD DUE TO ITS AFFORDABLE PRICES. WITH THE ONGOING TREND PV WILL BE ONE OF THE MOST IMPORTANT ENERGY SOURCES IN THE FUTURE.

OVERVIEW AND STATE OF THE TOPOLOGY

The inverter and PV-generator are treated as a system, if this system is grid independent i.e. stand-alone or off grid system. PV-modules are connected in combinations of series and parallel configurations to get a higher power level for the PV system. Very common is a series connection of modules (the cells inside the modules are connected in series, too). The series connection of modules is called a string.

The optional load connection arrangement shown in Fig 1, is basically the flip-flop logic, in which the output loads (i.e. optional loads) are monitored/ controlled by sun intensity-level during the entire day by using electronic circuitry.

FUNCTIONAL BLOCKS OF THE CIRCUIT

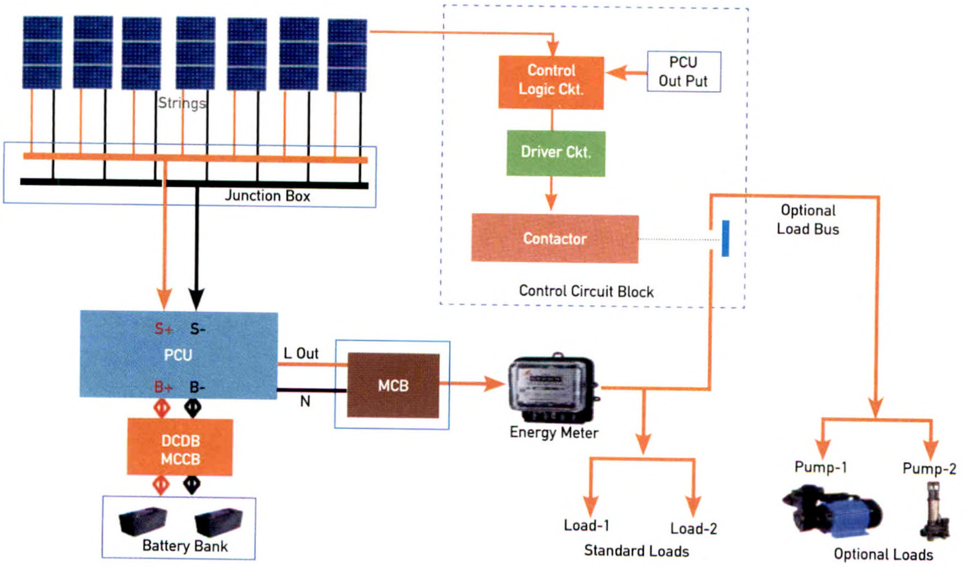
The insolation monitor circuit (electronic circuitry) is divided in to three sections:-

- power supply
- irradiation voltage amplifier
- power-contactor driver section.

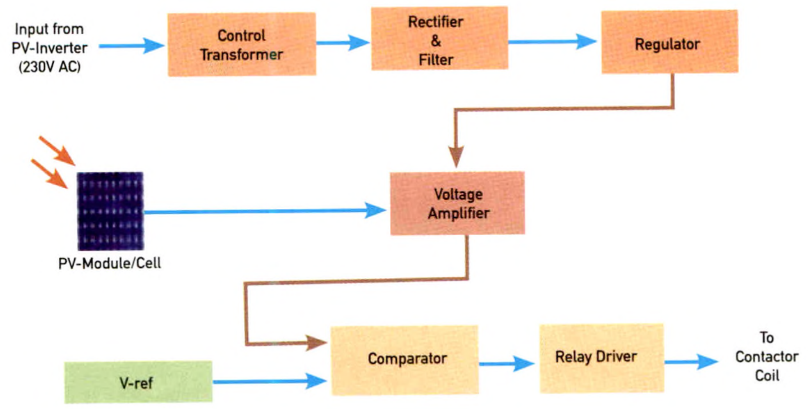
Power supply section: It provides power supply for entire circuit, to activate the components of the electronic circuit and consists of

- small control transformer
- bridge/centre taped full-wave rectifier, and
- filter capacitors with voltage regulators.

Irradiation voltage amplifier section: This section plays a vital-role in the circuit.

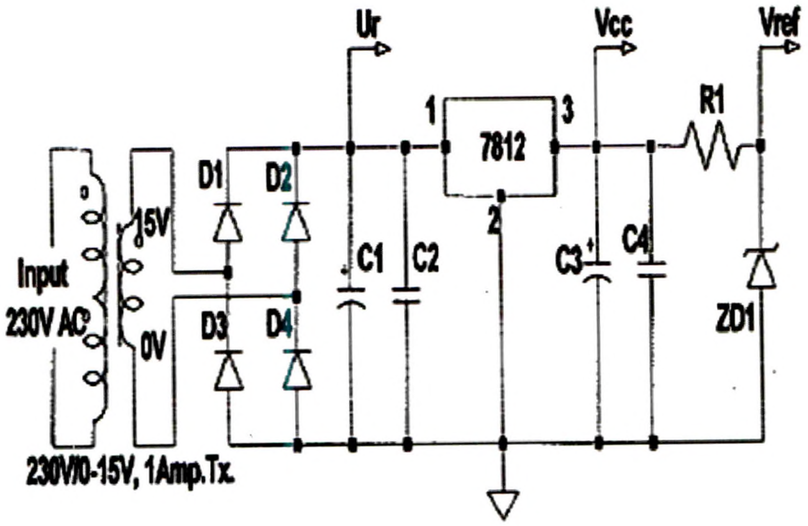


« FIG. 1: Configuration of topology arrangement



Block diagram for Insolation-monitor circuit

« FIG. 2: Block diagram of the circuit



INDEX
Ur = Unregulated power supply for relay driving.
Vcc = Regulated 12V dc supply for ICs etc.
Vr = Reference voltage (3.3V) for comparator.

« FIG. 3: Power supply section with filter capacitor

The circuit diagram shown in Fig.4, consists of ● irradiation amplifier section, and ● comparator section.

Irradiation amplifier section: The voltage drop across shunt resistance of SPV-cell/module is amplified from millivolts to volts; this amplified voltage will compare with Vr (3.3V ref. voltage) to switch-ON/OFF the relay/contactor, as per pre decided sun-intensity.

Power-contactor driving section: This section activates/deactivates the relay coil, to switch-ON or switch-OFF the contactor. Fig.5 shows the detailed circuit.

The main-components are; ● LM 358 IC (for comparators); ● SL 100-NPN transistors (to drive the 12V relays); ● 12V dc, 1C/O. 6 Amps relays (to drive the power-contactor).

Power wiring: This requires some modification in the output section. The output of the system will be connected to the optional loads via power-contactor. The connection diagram is shown in Fig 1.

As per the sun-intensity optional loads will be added/subtracted from the inverter output, to maintain battery bank health from the inverter output. Most of the battery drain-up issues will be resolved with this newly-proposed solution. One can charge the batteries during the day and utilize it as a backup at night for standard loads. No power will be exported to the optional loads at lower sun intensity with this solution. As per

PV SYSTEMS OFFER A WIDE RANGE OF POSSIBILITIES AND CONFIGURATIONS FOR THE USE OF POWER ELECTRONIC CONVERTERS.

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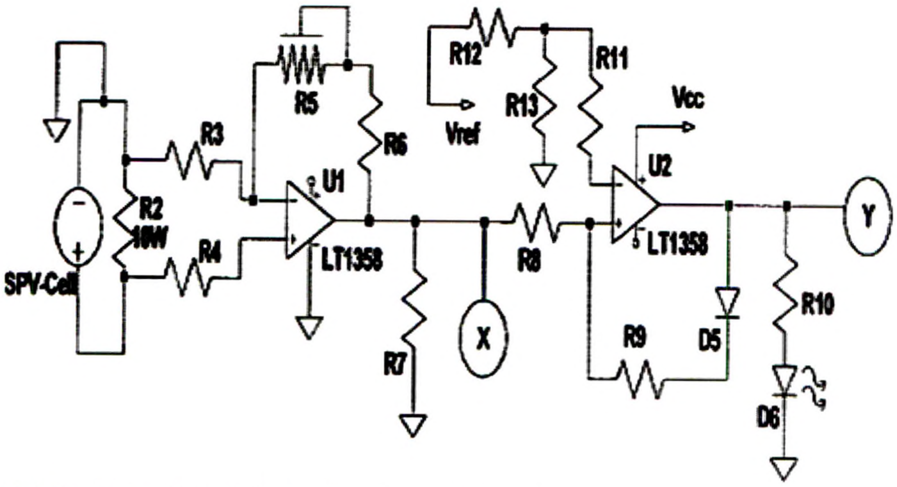


FIG. 4: Circuit diagram for irradiation amplifier and comparator section

this concept no bidirectional inverters, automatic switch-box etc. are required. It is an SPV-load management solution. As per sun-irradiation, the optional loads will come into the picture. It monitors the sun-irradiation as per the sun's intensity; the optional load is added or subtracted at inverter's output. For this, we designed a prototype-model automatic logic circuit(Fig. 6) at our Power Management Group Lab.

PROTOTYPE-MODEL

A prototype model kit was developed on a general purpose printed circuit board, with total control circuit i.e. power supply section with filter capacitor, irradiation amplifier and comparator section, relay/contractor driver circuit section. This prototype-kit is suitable for the operation of four optional loads, to stop the battery bank drain-up at lower irradiation/insolation for back-up of PV power systems.

CONCLUSION

PV-systems offer a wide range of possibilities and configurations for the use of power electronic converters. This given topology and the technology are presented as they are

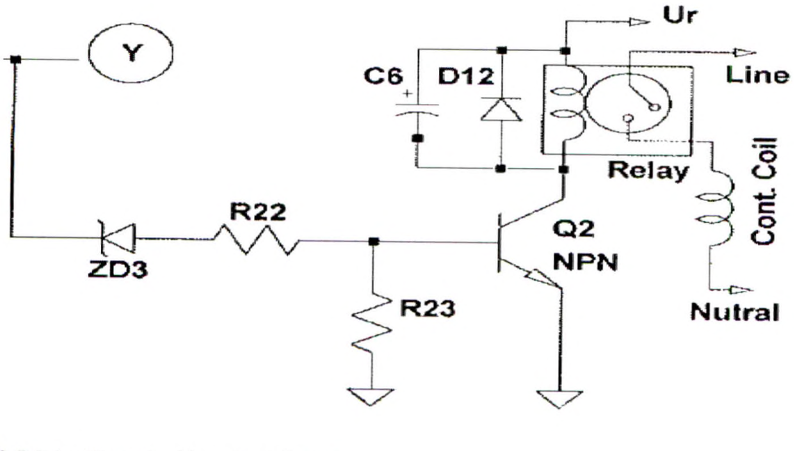
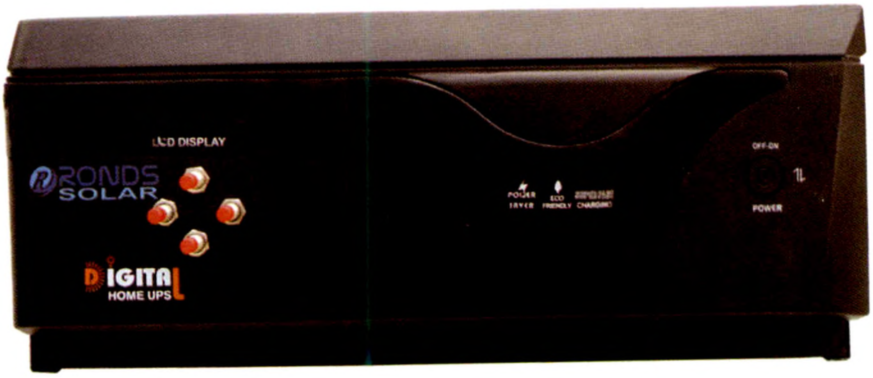


FIG. 5: Relay / Contactor driver circuit diagram



> FUTURE WORK WILL BE TO COMPARE TOPOLOGIES, WITH SPECIAL ATTENTION TO SIMULATION AND MEASUREMENTS ON AN EXPERIMENTAL SETUP.

promising and can be used successfully in the future for stand-alone, off grid PV systems. Future work will be to compare topologies, with special attention to simulation and measurements on an experimental setup.

ACKNOWLEDGMENT

I would like to thank Dr Jatin Roy and SI-team members for providing their contribution/suggestions for developing this invention.

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DID YOU KNOW?

1 If it could be properly harnessed, enough sunlight falls on the earth in just one hour to meet world energy demands for a whole year!

2 Ever the innovator, Albert Einstein won the Nobel Prize in Physics in 1921 for his ground-breaking experiments with solar power and photovoltaics.

3 The geothermal energy from the core of the Earth is closer to the surface in some areas than in others. Where hot underground steam or water can be tapped and brought to the surface, it can be used to generate electricity.

4 A world record was set in 1990 when a solar-powered aircraft flew across the USA in 21 stages, using no fuel at all.

5 The largest wind turbine in the world, located in Hawaii, stands 20 storeys tall and has blades the length of a football field.

6 An average wind speed of just 14mph is needed to convert wind energy into electricity.

7 Romans not only gave us the modern drainage system and many of our roads, they were also among the first to use geothermal energy to heat houses.

Source : The Independent (http://www.independent.co.uk)

ALGAE- A SOURCE OF BIOFUEL

The use of algae is an attractive option for generating biofuels. In fact, algae farming in less than 2-3 per cent of India's total land could satisfy the country's liquid fuel needs in the decades to come.

RENU SINGH, MONIKA SRIVASTAVA, SAPNA TIWARI

Some algae species are known to produce high levels of carbohydrates instead of lipids as reserve polymers.

Biofuels are any solid, liquid or gaseous fuels that are derived from living matter, either directly from plants or indirectly from agricultural, municipal, commercial or domestic wastes. First generation biofuels are derived from sugars, starch, vegetable oils or animal fats. Second generation biofuels are obtained from ligno-cellulosic biomass. Third generation biofuels or algae biofuels are produced from algae. Algae need primarily three components to grow: sunlight, carbon-dioxide and water. They use sunlight to form all kind of substances like sugars, protein, fat, vitamins etc. and are available in most geographical regions. In principle, a biochemical process converts the energy of sunlight into a form of chemical energy. Algae needs low input and gives high yield up to 30-100 times more. Algae like *Pleurochrysis carterae*, grows on the fresh or brackish water and thus does not compete with food crops. There is enough advancement in open ponds and closed photo-bioreactors for productivity and reliability of algae as a source of biomass for fuel. When physical conditions are stressful or certain nutrients are lacking, microalgae respond by producing more carbohydrates or lipids. Some algae species are known to produce high levels of carbohydrates (sugars and starch) instead of lipids (oils) as reserve polymers. Extensive research on algal biofuel regarding the algal strains, algae culture, harvesting and downstream process has been done.

BIODIESEL OBTAINED FROM ALGAL LIPID IS NON-TOXIC AND HIGHLY BIODEGRADABLE. MICROALGAE PRODUCE 15-300 TIMES MORE OIL THAN TRADITIONAL CROPS ON AN AREA BASIS.

ALGAE CULTIVATION INPUTS

Algae are simple microorganisms, which range from 0.2 µm in diameter, in pico-plankton, to large leaf like formations which are 60 m in length. Algae cultivation for biofuel production entails carbon dioxide, light, nutrients, optimum temperature and biomass harvesting.

- A dominant factor in algal growth is carbon dioxide (CO_2) which is used as a carbon source. No growth occurs in the absence of CO_2.
- Algae need sunlight as an energy source to perform photosynthesis. The rate of photosynthesis increases with the intensity of light.
- Algae require nutrients to grow, mainly nitrogen and phosphorous. These can be supplied in the form of agricultural fertilizers. Waste water effluents also contain a large amount of nitrogen and phosphorous and are thus useful for algal growth.
- Algae need optimum temperature for their growth. Water temperature of 20-35°C is good for high algal growth, depending on the species.
- Algae harvesting is very expensive due to its small size and low biomass concentration. After cultivation, more than 99 per cent by weight of the algae-water mixture is water. Separation of algae from water demands high energy and thus makes the process costly. About 20-30 per cent of the total cost of production of biomass is utilized for harvesting. Different techniques applied for biomass concentration and harvesting are settling ponds, filtration, centrifugation, flocculation and killing the cells with ultrasound.

BIO-ETHANOL PRODUCTION

Microalgae produce fermentable carbohydrates without lignin, which makes them an attractive feedstock for bio-ethanol production. Algae produce a mixture of methanol, ethanol, propanol, and butanol. Ethanol can be obtained from algae by two methods: saccharification and fermentation of algae and intracellular fermentation of algae. In the first method, the algae which has a good amount of starch (e.g. *Chlorella vulgaris*, 37 per cent) is harvested and saccharified to convert complex sugar into fermentable sugars by using suitable enzymes. Then the simple sugars are subjected to fermentation in the fermenter under controlled conditions i.e. pH, temperature etc; 65 per cent ethanol-conversion rate can be obtained. Therefore, algal starch proves to be a good source of ethanol production using the conventional process. Another type of ethanol production process is intracellular starch fermentation under dark and anaerobic conditions. Algal starch, which is photosynthetically accumulated in Chlamydomonas was observed to metabolize into low

Different production processes from algae

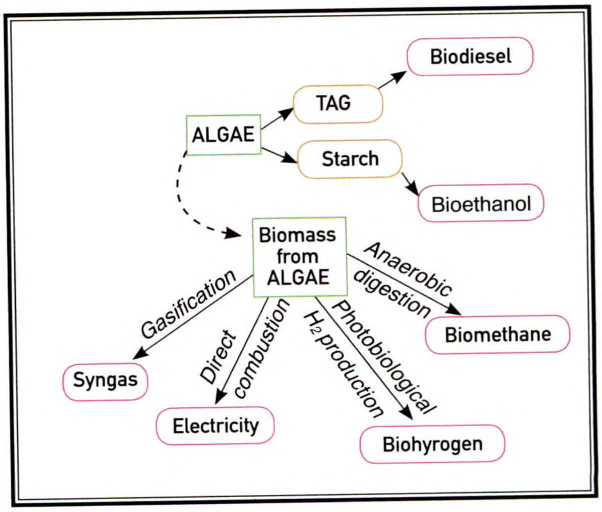


TABLE 1: Capacity addition in 2012-13 (as on 28th February 2013)

ADVANTAGES	DISADVANTAGES
High growth rate	Low biomass concentration
High efficiency in CO_2 mitigation	Higher capital costs
Less water demand than land crops	Inability to withstand fluctuating temperatures, seasonal change
More cost effective farming	

molecular weight compounds such as hydrogen, ethanol, glycerol and acetate under oxygen free, CO_2 atmosphere. Dark fermentation of green algae *Chlorococcum littorale*, which has 27 per cent cellular starch, yields maximum ethanol productivity of 450 umol/g-dry weight at 30°C.

BIODIESEL PRODUCTION

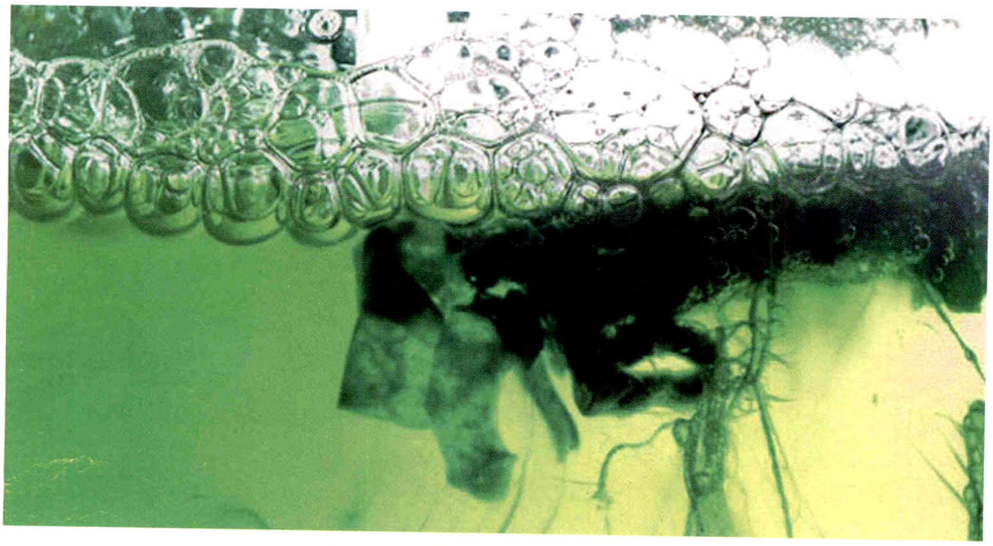
Biodiesel obtained from algal lipids is non-toxic and highly biodegradable. For the same area microalgae produce 15-300 times more oil for biodiesel production than traditional crops. Algal biomass contains three main component - proteins, carbohydrates, and natural oil. About 40 per cent of algal biomass is comprised of fatty acids, which can be extracted and converted into biodiesel. First, extraction of oil is carried out. Next the extracted oil is evaporated under vacuum to release solvent mixture solutions using rotary evaporator at 40-45 °C. Then, the oil produced from each algal species is mixed with a blend of catalysts such as sodium hydroxide and an alcohol such as methanol. This process is called trans-esterification. The algal biodiesel can be obtained after removing glycerol and other valuable products.

METHANE PRODUCTION

Methane can be produced from algae through anaerobic digestion or by pyrolysis/gasification process. It is important as electricity generation can also be used as a vehicle fuel. It is environment friendly as it generates relatively lesser amount of carbon dioxide for each unit of heat that is released.

BIO-HYDROGEN PRODUCTION

The production of hydrogen through biological processes, such as the one using algae can efficiently solve world's energy crisis. Algae can produce hydrogen during photosynthesis and it is possible to optimize hydrogen production by changing algal



« Biodiesel production from algae

surrounding conditions or through genetic manipulation. Biological production of hydrogen is better than the chemical processes, as biological processes are cost effective. There are numerous processes for the production of bio-hydrogen such as direct bio-photolysis, indirect bio-photolysis, non-photochemical, and deprivation.

Direct bio-photolysis: In this process, hydrogen is produced from water during the process of algal photosynthesis and sunlight is converted into chemical energy. Photo-system II (PSII) absorbs light energy and generates electrons which are transported to ferredoxin by using the light energy absorbed by photo-system I (PSI). In the end, hydrogenase enzyme accepts the electron from the reduced ferredoxin and generates hydrogen by using the available protons.

$$2H_2O \xrightarrow{\text{Light energy}} 2H_2 + O_2$$

Indirect bio-photolysis: Cyanobacteria or blue green algae can also produce hydrogen through photosynthesis. The process takes place in special structures known as heterocysts. They use water as an electron donor; oxygen is generated as a byproduct. Mainly, hydrogenase and nitrogenase enzyme are involved in this process. Hydrogen production has been assessed in 14 different genera of cyanobacteria under a wide range of culture conditions.

$$12H_2O + 6CO_2 \xrightarrow{\text{Light energy}} C_6H_{12}O_6 + 6O_2$$
$$C_6H_{12}O_6 + 12H_2O \xrightarrow{\text{Light energy}} 12H_2 + 6CO_2$$

Non-photochemical hydrogen production: In non-photochemical hydrogen production, starch is converted through glycolysis into pyruvate and NAD^+ oxidizes to NADH and H^+. Then the electron is transferred to plastoquinone pool by NAD(P)H plastoquinone reductase complex and finally photosystem I transfers the electron to ferredoxin which in turn transfers it to hydrogenases and hydrogen is produced. Under anaerobic conditions, through pyruvate-ferredoxin oxidoreductase complex, pyruvate oxidizes to acetyl-CoA and converts oxidized form of ferredoxin to reducing form, which is useful for hydrogen production.

Sulphur deprivation: Hydrogen is also produced through sulphur deprivation process. The rate of hydrogen production is enhanced many times by depriving *Chlamydomonas reinhardtii* of sulphur. During this process, the rate of oxygen formation and CO_2 fixation decreases significantly due to depletion of D1 in the PSII reaction centre. Deprivation of sulphur leads to depletion of D1 as D1 polypeptide chain consists of several sulphur containing amino acids such as cysteine and methionine. The photosynthetic rate decreases as compared to the mitochondrial respiration rate. Therefore, after sometime anaerobic condition arises. During partial inactivation of PS II, the electron generated through photolysis of water is accepted by the protons with the help of Fe-hydrogenase enzyme, and hydrogen is evolved.

CARBON CONSUMPTION

Algae use carbon dioxide as a major source of carbon for performing photosynthesis. CO_2 emitted by coal fired power plants, carbon intensive industries and transportation fuels can be removed by constructing an algae pond or farm. Algae consume emitted carbon dioxide for their growth and generate a number of biofuels such as bio-ethanol, biodiesel etc. Biofuels produced have a potential to replace fossil fuels and hence, reduce carbon emission efficiently. Algae yield greater volumes of biofuel per acre of production-about 2000 gallons of fuel per acre of production per year, which is better than any crop-

METHANE CAN BE PRODUCED FROM ALGAE THROUGH ANAEROBIC DIGESTION OR BY PYROLYSIS/ GASIFICATION PROCESS. IT IS ENVIRONMENT FRIENDLY AS IT GENERATES RELATIVELY LESSER AMOUNT OF CARBON DIOXIDE FOR EACH UNIT OF HEAT THAT IS RELEASED.

based biofuel production system such as sugarcane, which yields 450 gallons/acre/year, palm which yields 650 gallons/acre/year or corn which yields 250/acre/year. Algal biofuels has evolved as a carbon-neutral source for production of biofuel. The process will capture carbon dioxide, mitigate green house gas emission and provide an alternative to fossil fuels.

ACCORDING TO AN ESTIMATE, ALGAE FARMING IN LESS THAN 2-3 PER CENT OF INDIA'S TOTAL LAND WOULD MAKE THE COUNTRY SELF SUFFICIENT IN LIQUID FUEL.

CHALLENGES

The major challenges of producing biofuel from algae include strain isolation, nutrient sourcing and utilization, production management, harvesting, co-product development, fuel extraction, refining and residual biomass utilization. Technologies for extraction of oil from algae have been successfully demonstrated but are relatively expensive, in terms of equipment needed and amount of energy required to extract the oil. Also, there are some limitations with the handling of algae. The most common and important limitation is the danger of contamination that enhances the competition with the target species. If these problems are overcome, the advent of algal biofuel will definitely bring about development in the field of transport, power generation, and industries. Environmental issues such as global warming, carbon sequestration and food security may also be elucidated through algae cultivation.

POTENTIAL OF ALGAL BIOFUEL PRODUCTION IN INDIA

In India, a large quantity of waste water is extracted from industries, factories, municipal sewage etc. Municipal waste water of metro cities contains nutrients approximately 30-100 ppm of nitrogen, 10-45 ppm of phosphorous - which can be utilized for algal cultivation. Only, a small quantity of agricultural wastewater is recycled on farms, while most of it is discharged. This discharged water can be used for algal growth. All these techniques not only fulfill the nutrient needs of algae at a very cheap rate, but also provide a solution for treating wastewater. Large scale micro-algae cultivation can be done in coastal areas and in flat plain regions. Also, the Indian climate is suitable for algal growth. According to an estimate, algae farming in less than 2-3 per cent of India's total land would make the country self sufficient in liquid fuel. Although land, water and nutrient sources are easily available for cultivation of algae in India, but, its adaptation on a commercial scale would require development of new technologies. Harvested algae should be quickly extracted for algal crude oil. It should be compatible with the current engines. Technologies related to processing of algal crude into bio-methane or biodiesel should be developed at village level.

Biological production of hydrogen is better than the chemical processes as biological processes are cost effective.

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HARNESSING ELECTRICAL ENERGY THROUGH SOLAR CELL CONCENTRATORS

The efficiency of solar cells has increased from 4-5 per cent, when it was discovered in 1954, to 38-40 per cent due to the use of solar cell concentrators. These concentrators could bring down the total cost of solar cells, thus making solar technology cheaper and more affordable.

R. S. ROHELLA

The Sun has been producing energy for billions of years. Solar energy, which is a renewable source of energy, is the solar radiation that reaches the Earth. The Earth receives 2.9X1015 kW of energy every day in the form of electromagnetic radiation, which is about one hundred times the total energy consumption of the world in a year. The solar energy falling on earth has been quantified as 'Sun' and is approximately equal to 100 watts/ft^2 or 1000 watts/m^2. It can be converted to electricity by means of solar or photovoltaic (PV) cells.

PHOTOVOLTAICS

Photovoltaic (PV) systems convert light energy into electricity. The term 'photo' originates from the Greek 'phos' which means 'light' and 'volt' comes from Allessandro Volta (1745-1827), a pioneer in the study of electricity. 'Photo-voltaics', then, could literally mean 'light-electricity'. French physicist Edmond Becquerel first described the PV effect in 1839, but it remained a curiosity for the next three quarters of a century. Becquerel found that certain materials would produce small amounts of electric current when exposed to light. The effect was first studied in solids, such as selenium, by Heinrich Hertz in the 1870s. Soon afterward, selenium PV cells were used to convert light into electricity at 1 to 2 per cent efficiency. As a result, selenium was quickly adopted in the emerging field of photography for use in light-measuring devices. Major steps toward commercializing PV were taken in the 1940s and early 1950s, when the Czochralski process was developed for producing highly pure crystalline silicon. In 1954, scientists at Bell Laboratories depended on the Czochralski process to develop the first crystalline silicon PV cell, which had an efficiency of 4 per cent.

SOLAR CELLS

A solar cell is a device that directly converts light energy into electrical energy through the use of PV. The development of solar cell technology begins with the 1839 research of French physicist Antoine-César Becquerel. These early solar cells, however, still had energy-conversion efficiencies of less than 1 per cent. This impasse was finally overcome with the development of the silicon solar cell by Russell Ohl in 1941. Thirteen years later three other American researchers, G.L. Pearson, Daryl Chapin and Calvin Fuller, demonstrated a silicon solar cell capable of 6 per cent energy conversion efficiency when used in direct sunlight.

SOLAR CONCENTRATORS

A concentrator captures a large area of solar energy and focuses it onto a small area where the solar cells are mounted. The ratio of the two areas is called concentration ratio. A typical solar concentrator unit consists of a lens or mirrors to focus the light, a tracking system to collect the solar energy from dusk to dawn and a cooling mechanism to dissipate excess heat produced by concentrated sunlight on the solar cells. This process leads to greater power falling on the area of focus thereby increasing efficiency of conversion.

DEVELOPMENT OF SOLAR CONCENTRATORS

The solar cell has come a long way, from initial efficiency of 4 to 5 per cent in 1954 when it was discovered, to the developments of solar cell concentrators with an efficiency of 38-40 per cent, which was made possible through the development of different types of concentrators discussed below:

POINT FOCUS FRESNEL LENS SOLAR CELL CONCENTRATOR

The most prominent optical lens is the Fresnel lens. It was developed in 1822 for use in light houses, and can achieve high concentration ratios. Newer lenses such as aspheric lenses; and transmission, total internal reflection, refraction (TIR) lenses, having a concentration ratio of over 300 while being only 2 cm thick, have been found to be quite useful in solar concentrators.

LINE FOCUS PARABOLIC REFLECTIVE TROUGH CONCENTRATOR

The Australian National University (ANU) has developed a 20 kW PV trough concentrator with solar cells mounted on the under surface. The system comprised foundations, mirrors and support and aluminium passive heat sink-receivers. The above 20 kW solar concentrator featured two-axis continuous tracking. All trough modules are mechanically linked so that one motor actuates the tilt and the other actuates the roll. A time based, open loop central processing controller via a driver interface and position feedback system controlled both the motors. This allowed the concentrator to take full advantage of the daylight. The concentrator performed very well with an over system efficiency of 13 per cent while the cell efficiency was reported to be 22 per cent.

EUCLIDES PHOTOVOLTAIC CONCENTRATOR

The world's largest PV concentration grid-connected power plant, the EUCLIDESTM-THERMI plant has been installed by BP Solarex in the south of Tenerife in Spain. The plant is rated at 480 kWp and is composed of 14 parallel arrays each 84 meters long. Each array carries 138 modules and 140 mirrors. The modules are series connected in each array. The mirror technology is based on metallic reflective sheets shaped with ribs to the parabolic profile. The modules are cooled with a passive heat sink. Two contiguous arrays are connected in parallel to one inverter of 60 kVA. The output voltage at standard operating conditions is 750 Volts. The concentrating optics uses mirrors instead of Fresnel lenses, which were used previously in all PV concentration developments. The tracking system is one axis and horizontal since it is cheaper than the two-axes tracking systems. The concentrating schemes present a more constant output than the flat panels. The system is cost effective and thus might present some advantage in the value of the electricity produced.

EUCLIDESTM-THERMI IS THE WORLD'S LARGEST PV CONCENTRATION GRID-CONNECTED POWER PLANT, RATED AT 480 KWP AND COMPOSED OF 14 PARALLEL ARRAYS EACH 84 METERS LONG.

PARABOLIC REFLECTIVE DISH CONCENTRATOR

In the recent years, two more configurations are possible for solar concentrators. The Solar Research Corporation (SRC) has developed a reflective dish concentrator. Solar Systems Pvt Ltd, an affiliated company of The SRC has installed two such concentrator systems in Australia made up of parabolic dishes, each producing 22 kW. One such system with 10 parabolic dishes will be installed in the Anangu Pitjantjatjara Lands (South Australia). The system is powered by a 130 m2 parabolic dish and can generate approximately 20 kW of AC power. The other system with 42 parabolic dishes will be installed at a 20-hectare solar farm at Broken Hill.

DENSE PACKED ARRAY PHOTOVOLTAIC CONCENTRATOR BY AMONIX

Relatively low-concentration systems were first built using individual cells, each with its own concentrator optics. But no further large-scale projects were undertaken until recently. Amonix has designed and installed a large-scale system using individual cells at a very high concentration (260X). The most important advantages of this type of individual-cell concentrator system are: (i) Most of the optics can be controlled at the time of manufacture so that fewer items need to be accurately aligned in the field. (ii) No fail safe provisions need to be included to prevent concentrated flux from causing damage in the event of erroneous sun tracking. (iii) The modules are sealed, flat panels, rendering cleaning a comparatively easy task. (iv) The cells are passively cooled. Thus, there are no fluids to handle and no fail safe provisions need to be incorporated to prevent damage caused by loss-of-coolant events.

DENSE PACKED ARRAY PHOTOVOLTAIC CONCENTRATOR

Spectrolab USA designed, fabricated and tested two dense packed modules using high efficiency multi-junction cells. Test results were very encouraging with cell area based efficiencies over 25 per cent. Further improvements in the new designs are possible for higher efficiency.

PHOTOVOLTAIC CAVITY CONVERTER

A concentrating PV module is provided which gives a concentration in the range of about 500 to over 1,000 suns and a power range of a few kW to 50 kW. A plurality of such modules may be combined to form a power plant capable of generating over several hundred megawatts. The concentrating photovoltaic module is based on a Photovoltaic Cavity Converter (PVC) as an enabling technology for very high solar-to-electricity conversions. The use of a cavity containing a plurality of single junction solar cells of different energy band gaps and the simultaneous spectral splitting of the solar spectrum employs a lateral geometry in the spherical cavity (where the cell strings made of the single junction cells operate next to each other without mutual interference). The purpose of the cavity with a small aperture for the pre-focused solar radiation is to confine (trap) the photons so that they can be recycled effectively and used by the proper cells.

MULTI-JUNCTION CELLS FOR HIGHER EFFICIENCY

Non-silicon cells have not achieved the same degree of efficiency as Si cells. Emcore, USA has developed multi-junction solar cells using GaAs and GaSb. Multi-junction solar cell technology employs three solar cells in series, with each cell tuned to absorb a different colour of light. This technique converts more sunlight to electricity and thus the multi-junction cells with x1000 concentration thereby can operate at much higher efficiency of the order of 38 per cent as compared to 28 per cent for the single junction cells.

AN ADVANTAGE OF THE CONCENTRATOR IS THAT IT CAN USE SMALL INDIVIDUAL CELLS, WHICH ARE EASIER TO PRODUCE THAN LARGE-AREA, HIGH-EFFICIENCY CELLS.

MULTI-JUNCTION SOLAR CELL AND PANELS FOR SPACE COMMUNICATION

Emcore, an USA based company reputed with very high efficiency solar cell technology in terrestrial applications, is claiming a big success in solar power for space applications. With an overall efficiency of 28.5 per cent, the multi-junction technology has completely changed the mode of the solar power generation in space applications.

CONCENTRATOR AND SPACE APPLICATIONS OF HIGH-EFFICIENCY SOLAR CELLS : RECENT DEVELOPMENTS

The two-junction (cascade) Ga0.5In0.5P/GaAs cell was invented in November 1984 at the National Renewable Energy Laboratory (NREL). Over the next few years, the growth and basic properties of Ga0.5In0.5P were studied. As the purity of the source materials was improved and the device optimised, the efficiencies climbed: 4 per cent in 1985, 10 per cent in 1987, 21.8 per cent in 1988, and 27.3 per cent in 1990. When the two-junction efficiencies passed the efficiency of single junction GaAs, the cascade cell became attractive for space applications. The cascade cells provide a higher efficiency, lower temperature coefficient, improved radiation resistance and reduced series-resistance losses.

ADVANTAGES AND DRAWBACKS

Using solar energy has many advantages as well as disadvantages. Solar concentrators increase cell efficiency under concentrated light. The increase in efficiency depends largely on the cell design and material used. Another advantage of the concentrator is that it can use small individual cells, because it is harder to produce large-area, high-efficiency cells than it is to produce smaller-area cells.

There are, on the other hand, several drawbacks to using concentrators. The concentrating optics is significantly more expensive than the simple covers needed for flat-plate modules and most concentrators must track the sun throughout the day and year to be effective. Thus, higher concentration ratios mean using not only expensive tracking mechanisms but also more precise controls than flat-plate systems with stationary structures. Also, a large area is needed to put up the solar plants.

CONCLUSIONS

Solar energy has vast potential, but its contribution to the world's energy market is still very limited. Solar concentrators could bring down the total cost of the solar cells, thus making the solar technology cheaper and more affordable. At the same time it does not compromise the overall performance of the solar technology. The technology is yet not matured enough for economically harnessing solar power on a large scale. It is still capital intensive and lacks long term reliability. For about a decade, the developmental of solar concentrators in many advanced countries has been in full swing. If the prototypes with more than 40 per cent efficiency perform well, solar plants which are stand-alone or with co-generation medium will soon become a reality.

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India's first fuel cell bus developed by Tata Motors Limited (TML) and Indian Space Research Organisation (ISRO)

FUEL CELL TECHNOLOGY

In fuel cells, the chemical energy available in the fuel is converted directly into electricity, providing higher efficiency. Heat which is generated from fuel cells can be treated as a by-product of the conversion process and can be used for other purposes.

USHA RAGHAVAN

Fuel cells are electrochemical devices capable of converting chemical energy from fuel to electrical energy through a chemical reaction with oxygen or an oxidizing agent. The energy conversion in fuel cell is thus an electrochemical energy conversion. Hence it does not involve any type of mechanical movement for the process leading to a higher lifetime and efficiency. It is silent in operation. In conventional approaches, chemical energy of the fuel is converted initially into heat energy and finally into useful forms. This reduces the efficiency of the system. In fuel cells, the chemical energy available in the fuel is converted into electricity and eliminates the conversion into heat, hence providing higher efficiency. Heat which is generated from fuel cells can be treated as a by-product of the conversion process and can be used for other purposes.

WHAT IS A FUEL CELL?

In principle, a fuel cell operates like a battery. Unlike a battery, a fuel cell does not discharge. A fuel cell consists of an electrolyte and two electrodes. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat. Hydrogen fuel is fed into the 'anode' of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. Assisted by a catalyst, the hydrogen atom splits into a proton and an electron that takes different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen ion and oxygen to form a molecule of water.

In a typical fuel cell, hydrogen fuel, or hydrogen rich fuel, and oxygen are combined in the presence of a catalyst to generate electricity by the oxidation – reduction reaction. It involves an oxidation half reaction at the anode and reduction half reaction at the cathode. The specific half reactions vary depending on the type of fuel cell. Fuel cells have been developed by changing the type of electrolyte used.

TYPES OF FUEL CELLS

PHOSPHORIC ACID FUEL CELL (PAFC): Phosphoric acid fuel cells use liquid phosphoric acid as the electrolyte and operate at about 450°F. One of the main advantages to this type of fuel cell, besides nearly 85 per cent cogeneration efficiency, is that it can use impure hydrogen as fuel. PAFCs can tolerate a CO concentration of about 1.5 per cent, which broadens the choice of fuels they can use. PAFCs generate electricity at more than 40 per cent efficiency - and nearly 85 per cent of the steam this fuel cell produces is used for cogeneration.

PROTON EXCHANGE MEMBRANE (PEM): PEM fuel cells use thin, solid, organic polymer as the electrolyte and operate at relatively low temperatures (175°F). They have an efficiency of 25-30 per cent.PEMs have high power density, can vary their output quickly to meet shifts in power demand, and are suited for applications such as in automobiles, where quick startup is required. This type of fuel cell is sensitive to fuel impurities. Cell outputs generally range from 50 watts to 75 kW.

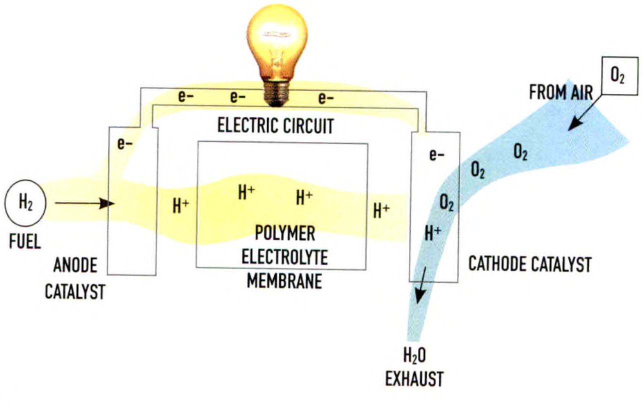
The high temperature-PEM fuel cells operate at temperatures between 250°F and 390°F. The membrane electrode assemblies consist of proton conductive polymer or a polymer doped with a proton conductive compound. HT-PEM fuel cells have been proven to tolerate up to 3 per cent CO.

MOLTEN CARBONATE FUEL CELL (MCFC): Molten carbonate fuel cells use an electrolyte composed of a molten carbonate salt mixture (Carbonates of Lithium, sodium or potassium) suspended in a porous, chemically inert matrix, and operate at high temperatures - approximately 1,200°F.They require carbon dioxide and oxygen to be delivered to the cathode. They are used for large scale power generation. MCFCs have an efficiency of 45-55 per cent. Cell output ranges from 10 kW – 10 MW.

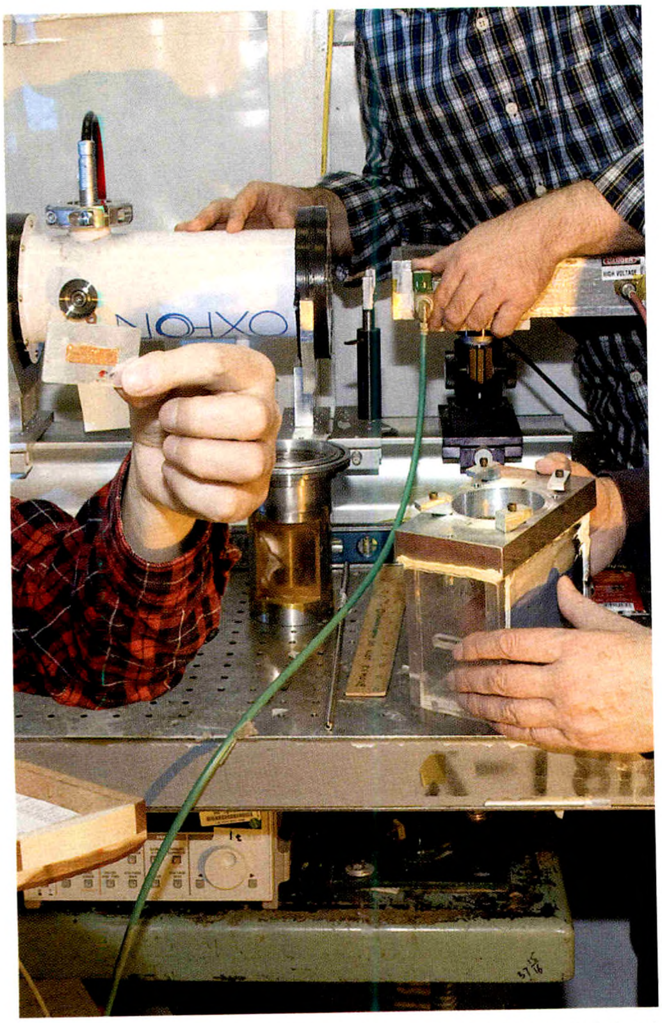
SOLID OXIDE FUEL CELL (SOFC): Solid oxide fuel cells use a hard, non-porous ceramic compound as the electrolyte, and operate at very high temperatures - around 1800°F. They are used for small to large-scale power generation. SOFCs have an efficiency of 45 - 60 per cent Cell output ranges from 1 kW – 10 MW. They are suitable for auxiliary power units used in vehicles to power the electronic circuits.

ALKALINE FUEL CELL (AFC): Alkaline fuel cells use potassium hydroxide as the electrolyte and operate at 160°F.They can achieve power generating efficiencies of 70 %. They are susceptible to carbon contamination. Hence they require pure hydrogen and oxygen. They are used in space vehicles and submarines.

DIRECT METHANOL FUEL CELL (DMFC): Like PEM cells, they use polymer membranes as electrolytes. It typically operates at a temperature between 120°F and 190°F. It has an efficiency of 20- 40 per cent. Cell output ranges from 3 kW – 250kW. It can be used for powering mobiles and laptops. The anode catalyst draws hydrogen from liquid methanol.



Fuel Cell



Scientists of U. S. Department of Energy's Brookhaven National Laboratory developed catalyst for fuel cells in 2010 and were awarded three patents for it.

MICROBIAL FUEL CELL (MFC): Microbial fuel cells use the catalytic reaction of microorganisms such as bacteria to convert organic material into fuel. Enclosed in oxygen-free anodes, the organic compounds are oxidized by the bacteria or other microbes. The electrons are pulled from the compound and conducted into a circuit with the help of an inorganic mediator. MFCs operate at low temperatures, such as 20-40°C, and have 50 per cent efficiency. These cells are suitable for small scale applications.

PROTONIC CERAMIC FUEL CELL (PCFC): This fuel cell is based on a ceramic electrolyte material that exhibits high protonic conductivity at elevated temperatures (700° C).The high operating temperature is necessary to achieve very high electrical fuel efficiency with hydrocarbon fuels. PCFCs have a solid electrolyte so that the membrane cannot dry out as with PEM fuel cells, or liquid can't leak out as with PAFCs.

FUEL CELL COMPONENTS

Physical components play a very significant role in the performance of the fuel cell. The main physical components are electrolyte/ membrane, electrode, gas diffusion layer, sealant, bipolar plate/ interconnect, end plate/ collector. The membrane plays a vital role in the electrical performance of the fuel cell. Some of the properties of the membrane/ electrolyte that influence the performance are ionic conductivity, gas permeability, modulus of elasticity of the membrane, and thickness.

Electrode is the bridge between the electronic conductor and ionic conductor. The electrodes must have the property of the membrane and should be a good electron conductor. The catalyst used on the electrode, surface area, porosity, and hydrophobicity are crucial properties of the electrodes that can affect fuel cell performance.

The gas diffusion layer provides mechanical support to the electrodes. Porosity of this layer should be high to allow gas flow. To avoid water accumulation in the diffusion layer, the hydrophobicity should be high. Also the electronic conductivity must be high to eliminate resistive losses. Sealant reduces the operational cost by reducing the wastage of fuel and provides safety. The thickness of gasket has to match with the thickness of the diffusion layer. Bipolar plate acts as an internal current collector in fuel cell stack. Electrical conductivity, thermal conductivity, porosity, density and hardness of the bipolar plate are some parameters that influence the performance of the fuel cell. End plates are used at both the ends of the fuel cell stack to hold the stack.

BENEFITS OF FUEL CELLS

A fuel cell power plant creates very less pollution compared to the pollution caused by conventional combustion generating systems. Fuel cell vehicles, operating on hydrogen stored on-board produce zero pollution. Fuel cell power generation systems today achieve 40 to 50 per cent fuel-to-electricity efficiency by using hydrocarbon fuels. More efficient systems are under development. Fuel cells are scalable. Fuel cells can be stacked until the desired power output is reached. They are light in weight and hence can be used in portable equipment. Fuel cell systems must be cost effective and perform at par with traditional power technologies. These challenges can be overcome by identifying and developing new materials.

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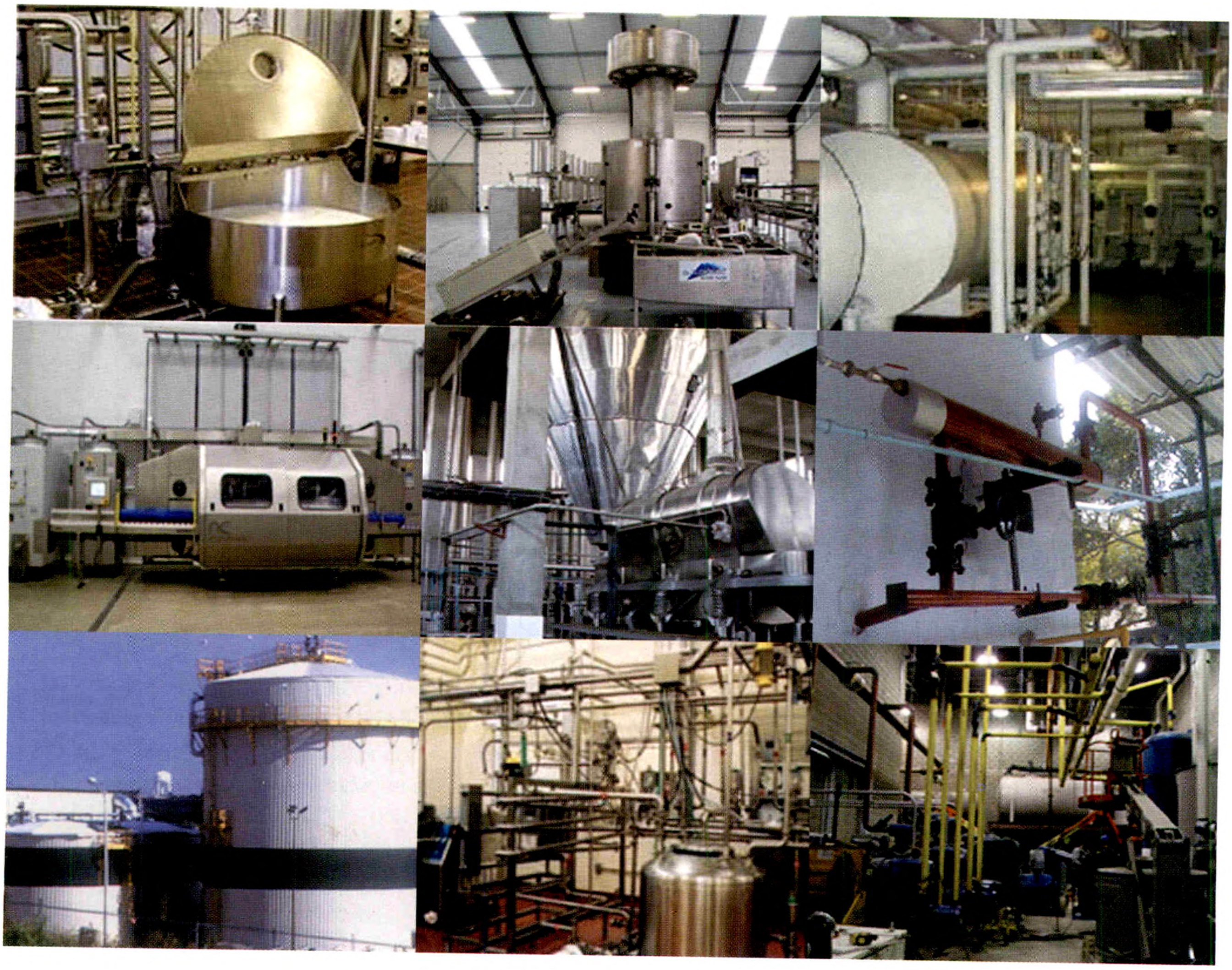
THERMAL ENERGY STORAGE

Energy storage systems are designed to accumulate energy when production exceeds demand and to make it available at the user's request. They can help match energy supply and demand, exploit the variable production of renewable energy sources, increase the overall efficiency of the energy system and reduce CO_2 emissions.



Thermal energy storage (TES) includes a number of different technologies. Thermal energy can be stored at temperatures from - 40°C to more than 400°C as sensible heat, latent heat and chemical energy (i.e. thermo-chemical energy storage) using chemical reactions. Energy storage systems are designed to accumulate energy when production exceeds demand and to make it available at the user's request. They can help match energy supply and demand, exploit the variable production of renewable energy sources (e.g. solar and wind), increase the overall efficiency of the energy system and reduce CO_2 emissions. An energy storage system can be described in terms of the following properties:

Capacity: The energy stored in the system depends on the storage process, the medium and the size of the system.

Power: Defines how fast the energy stored in the system can be discharged (and charged).

Efficiency: The ratio of the energy provided to the user to the energy needed to charge the storage system. It accounts for the energy loss during the storage period and the charging/discharging cycle.

Storage period: Defines how long the energy is stored and lasts in hours to months (i.e. hours, days, weeks and months for seasonal storage).

Charge and discharge time: Defines how much time is needed to charge/discharge the system.

Cost: Refers to either capacity or power of the storage system and depends on the capital and operation costs of the storage equipment and its lifetime (i.e. the number of cycles).

Capacity, power and discharge time are interdependent variables and in some storage systems, capacity and power can also depend on each other. For example, in TES systems, high power means enhanced heat transfer (e.g. additional fins in the heat exchanger), which, for a given volume, reduces the amount of active storage material and thereby the capacity.

IN TES SYSTEMS, HIGH POWER MEANS ENHANCED HEAT TRANSFER, WHICH, FOR A GIVEN VOLUME, REDUCES THE AMOUNT OF ACTIVE STORAGE MATERIAL AND THEREBY THE CAPACITY.

SENSIBLE THERMAL ENERGY STORAGE

The use of hot water tanks is a well known technology for thermal energy storage. Hot water tanks serve the purpose of energy saving in water heating systems based on solar energy and in co-generation (i.e. heat and power) energy supply systems. Hot water storage systems used as buffer storage for domestic hot water (DHW) supply are usually in the range of 500 litres to several cubic meters. This technology is also used in solar thermal installations for DHW combined with building heating systems (solar-combi-systems). Large hot water tanks are used for seasonal storage of solar thermal heat in combination with small heating systems.

UNDERGROUND THERMAL ENERGY STORAGE (UTES)

UTES is also a widely used storage technology, which makes use of the underground as a storage medium for both heat and cold storage. UTES technologies include borehole storage, aquifer storage, cavern storage and pit storage. These technologies strongly depend on local geological conditions.

Borehole storage: It is based on vertical heat exchangers installed underground, which ensure the transfer of thermal energy to and from the ground layers (e.g. clay, sand, rock). Ground heat exchangers are also frequently used in combination with heat pumps where the ground heat exchanger extracts low-temperature heat from the soil.

Aquifer storage: Its uses a natural underground water-permeable layer as a storage medium. The transfer of thermal energy is achieved by mass transfer (i.e. extracting/re-injecting water from/into the underground layer). Most applications deal with the storage of winter cold to be used for the cooling of large office buildings and industrial processes in the summer.

Cavern storage and pit storage: It is based on large underground water reservoirs created in the subsoil to serve as thermal energy storage systems. These storage options are technically feasible, but applications are limited because of the high investment costs.

PHASE CHANGE MATERIALS FOR TES

Sensible heat storage is relatively inexpensive, but its drawbacks are low energy density and variable discharging temperature. These issues can be overcome by phase change material (PCM)-based TES, which enables higher storage capacities and target oriented discharging temperatures. The change of phase could be either a solid/liquid or a solid/solid process. Melting processes involve energy densities in the order of 100 kWh/m^3 (e.g. ice) compared to a typical 25 kWh/m^3 for sensible heat storage options. Phase change materials can be used for both short term (daily) and long term (seasonal) energy storage, using a variety of techniques and materials.

THERMAL ENERGY STORAGE VIA CHEMICAL REACTIONS

High energy density (i.e.300 kWh/m^3) TES systems can be achieved using chemical reactions (e.g. thermo-chemical storage-TCS). Thermo-chemical reactions, such as adsorption (i.e. adhesion of a substance to the surface of another solid or liquid), can be used to store heat and cold, as well as to control humidity. Typical applications involve adsorption of water vapour to silica-gel or zeolites (i.e. micro-porous crystalline alumino-silicates). Of special importance for use in hot/humid climates or confined spaces with high humidity are open sorption systems based on lithium-chloride to cool water and on zeolites to control humidity.

APPLICATION

Important fields of application for TES systems are in the building sector (e.g. domestic hot water, space heating, air-conditioning) and in the industrial sector (e.g. process heat and cold). TES systems can be installed as either centralized plants or distributed devices. Centralized plants are designed to store waste heat from large industrial processes, conventional power plants, combined heat and power plants and from renewable power plants, such as concentrated solar power (CSP). Their power capacity ranges typically from hundreds of kW to several MW (i.e. thermal power). Distributed devices are usually buffer storage systems to accumulate solar heat to be used for domestic and commercial buildings (e.g. hot water, heating, appliances). Distributed systems are mostly in the range of a few to tens of kW. Manufacturing industry (e.g. automobile industry) can also benefit significantly from TES.

COSTS OF TES SYSTEMS

Cost estimates of TES systems include storage materials, technical equipment for charging and discharging, and operation costs. TES systems for sensible heat are rather inexpensive as they consist basically of a simple tank for the storage medium and the equipment to charge/discharge.

- Storage media (e.g. water, soil, rocks, concrete or molten salts) are usually relatively cheap. However, the container of the storage material requires effective thermal insulation, which may be an important element of the TES cost. Most systems consist of a 5,000-10,000 m^3 water container with energy content between 70-90 kWh/m^3 and investment costs between 50-200 EURO/m^3 of water equivalent, thus translating into a specific investment cost from 0.5-3.0 EURO per kWh.

TES SYSTEMS FOR SENSIBLE HEAT ARE RATHER INEXPENSIVE AS THEY CONSIST BASICALLY OF A SIMPLE TANK FOR THE STORAGE MEDIUM AND THE EQUIPMENT TO CHARGE/DISCHARGE.

- In the case of UTES systems, boreholes and heat exchangers to activate the underground storage are the most important cost elements. Specific costs range from 0.1-10 EURO per kWh and depend heavily on local conditions.
- Phase change material (PCM) storage and TCS systems are significantly more complex and expensive than the storage systems for sensible heat. In most cases (e.g. thermo-chemical reactors), they use enhanced heat and mass transfer technologies to achieve the required performance in terms of storage capacity and power, and the cost of the equipment is much higher than the cost for the storage material. In general, the cost of a PCM system ranges between 10 and 50 EURO per kWh. The difference between the pure PCM and the complete TES system is even higher for active PCM installations.
- Materials for TCS are also expensive as they have to be prepared (e.g. pelletized or layered over supporting structures). Containers and the auxiliary TCS equipment are expensive also for both heat and mass transfer during energy charging and discharging. TCS systems can be operated as either open systems (i.e. basically packed beds of pellets at ambient pressure) or closed systems. Open systems are often the cheapest option while closed systems need sophisticated heat exchangers. The TCS cost ranges from 8-100 EURO per kWh. The overall economic evaluation of a TES system depends significantly on the specific application and operation needs, including the number and frequency of storage cycles.

POTENTIAL AND BARRIERS

TES technologies face some barriers to market entry and cost is a key issue. TES market development and penetration varies considerably, depending on the application fields and regions. Penetration in the building sector is comparably slow in Europe where the construction of new buildings is around 1.3 per cent per year and the renovation rate is around 1.5 per cent; of course, the integration of TES systems is easier during construction. The estimate of the European potential is based on a 5 per cent implementation rate of TES systems in buildings. Penetration could be much higher in emerging economies with their high rates of new building construction. TES potential for co-generation and district heating in Europe is also associated with the building stock. The implementation rate of co-generation is 10.2 per cent, while the implementation of TES in these systems is assumed to be 15 per cent. As far as TES for power applications is concerned, a driving sector is the concentrating solar power (CSP) where almost all new power plants in operation or under construction are equipped with TES systems, mostly based on molten salt. This is perhaps the most important development field for large, centralized TES installations. In the industrial sector, about 5 per cent of the final energy consumption is assumed to be used by TES installations. In particular, the use of industrial waste heat is expected to grow since the price of fossil fuels will rise and energy efficiency will be the key to competitiveness. Other barriers relate to material properties and stability, in particular for TCS. Each storage application needs a specific TES design to fit specific boundary conditions and requirements. Research and development activities focus on all TES technologies. Most of such efforts deal with materials (i.e. storage media for different temperature ranges), containers and thermal insulation development. More complex systems (i.e. PCM, TCS) require research and development efforts to improve reacting materials, as well as a better understanding of system integration and process parameters.

APPLICATION OF THERMAL ENERGY IN HARNESSING SOLAR ENERGY

Thermal applications are drawing increasing attention in the solar energy research field, due to their high performance in energy storage density and energy conversion efficiency. In these applications, solar collectors and thermal energy storage systems are the two core components. Concentrating solar thermal power, more commonly referred to as CSP, is unique among renewable energy generators because even though it is variable, like solar PV and wind, it can easily be coupled with TES as well as conventional fuels, making it highly dispatchable. A multitude of advancements have taken place in recent years in an effort to make CSP more cost effective. Ongoing research efforts are in the areas of reflector and collector design and materials, heat absorption and transport, power production and thermal storage. The availability of storage capacity is expected to play an important role in the adoption of CSP plants by electrical utilities. By coupling TES with a CSP plant, the thermal energy can be stored for later use to drive a heat engine. TES has several advantages when compared to mechanical or chemical storage technologies. TES generally has lower capital costs as compared to other storage technologies, as well as very high operating efficiencies. A TES prototype system that was incorporated into the Solar Two project in Daggett, California demonstrated a round-trip efficiency greater than 97 per cent and which was defined as the ratio of the energy discharged to the energy stored in the TES system.

Several studies showed that addition of a TES system would result in the following:

- By taking into account the efficiencies of all plant components, TES can improve the annual solar-to-electric efficiency (13.2 vs 12.4 per cent), though it slightly lowers the steam cycle efficiency (37.5 vs 37.9 per cent) due to the lower steam temperatures that occur while TES is in use. The two main reasons for the increased annual efficiency were (a) much reduced need to dump energy during very high insolation periods and (b) lower turbine start-up losses due to buffering of the intermittent periods.
- The annual Levelised Cost of Energy (LCOE) is reduced by 10 per cent because of the higher capacity factor.
- Slight increases in the thermal losses in the receiver because of the higher HTF return temperature to the solar field.
- Two types of losses occur: thermal losses from the TES storage system, and losses when the storage system is full and the power plant cannot accept more energy because it is already at maximum load.
- Requires a larger solar field compared to the one without storage.
- Increases the capital cost but produces more energy resulting in a lower cost of electricity.
- Electric parasitics are slightly lower with TES because of the higher annual generation and lower percentage of off-line parasitic consumption.
- Turbine start-up becomes a smaller fraction of total energy use since it is operated for more hours with fewer starts. ✪

Inputs from IEA-ETSAP and IRENA Technology Brief E21 – 2013

PRODUCTION OF BIO-METHANOL

Bio-methanol can be produced from waste biomass, non-biogenic waste streams or even CO_2 from flue gases. At present, about 200,000 tonnes of bio-methanol are produced every year. However, plans exist to increase the global capacity to well over one million tonnes within a few years.

Bio-methanol plant, BioMCN, in Netherlands

Methanol is one of the most important platform chemicals produced by the chemical industry. Presently, methanol is used to make various other chemicals, converted into anti-knocking agents and blended with fuels and applied as a solvent and anti-freeze. Current research is looking into possibilities to use methanol as a transportation fuel (e.g. after conversion to dimethyl ether), as an energy carrier in general in a so-called methanol economy, and for the production of other basic chemicals (i.e. ethylene, propylene in particular). The present global production of 45 million tonnes per year is based almost entirely on fossil fuels, mainly natural gas. Concerns over climate change, fossil fuel depletion and natural gas prices have sparked interest in using renewable feedstock for the production of bio-methanol. Bio-methanol can be produced from virgin or waste biomass, non-biogenic waste streams or even CO_2 from flue gases. These feed-stocks are converted (typically through gasification) into syn-gas, a mixture of carbon monoxide, hydrogen and other molecules. To decrease the environmental impact of bio-methanol production, it has been proposed to use renewable electricity to supply the required hydrogen through electrolysis. Bio-methanol is chemically identical to conventional methanol. At present, about 200,000 tonnes of bio-methanol are produced every year. However, plans exist to increase the global capacity to well over one million tonnes within a few years.

> THE PRODUCTION OF BIO-METHANOL WILL REDUCE THE NEED FOR FOSSIL FUEL AND NUCLEAR ENERGY CONSUMPTION AND WILL REDUCE GREENHOUSE GAS (GHG) EMISSIONS.

PRODUCTION PROCESS

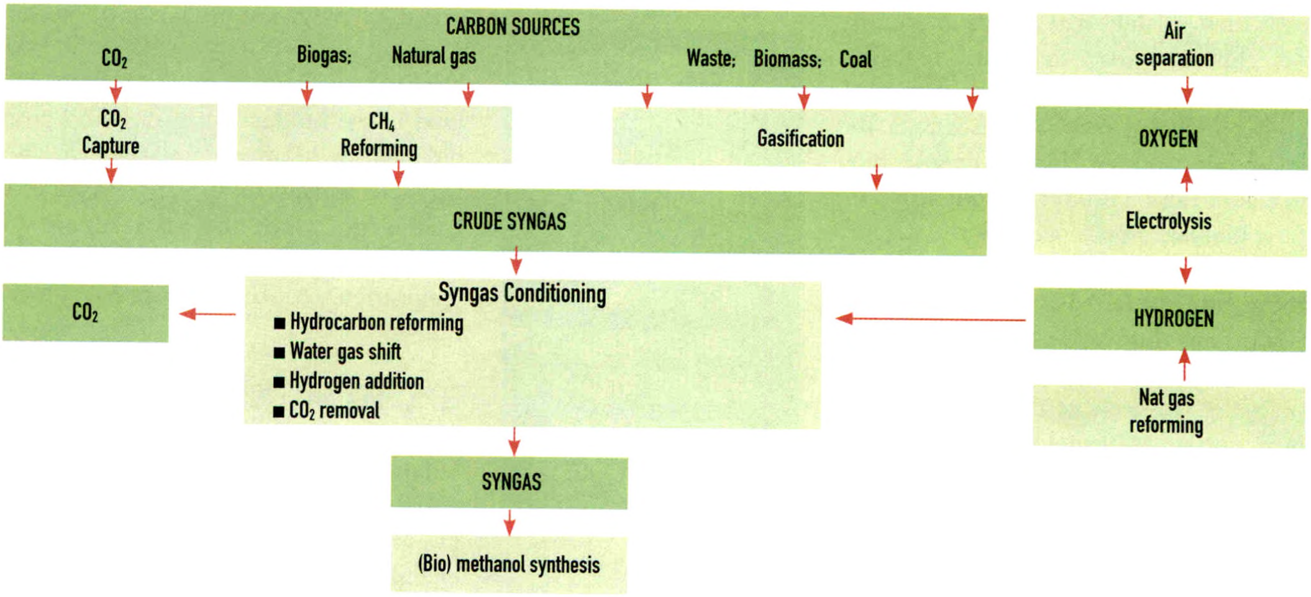
Methanol can be produced from concentrated carbon sources, such as natural gas, coal, biomass, by-product streams or even carbon dioxide (CO_2) from flue gases. In general, the plant configurations used for bio-methanol production shows strong similarities to coal-based methanol production via gasification, with two notable exceptions: bio-methanol from bio-gas (which is similar to methanol production from natural gas) and bio-methanol from CO_2. The main processes in a conventional methanol plant are: gasification, gas cleaning, syn-gas conditioning (reforming of high hydrocarbons, water-gas shift, hydrogen addition, CO_2 removal) and methanol synthesis and purification. First, a specific syn-gas composition can be reached by combining syn-gas from different sources or gasifying different feed-stocks simultaneously. The crude syn-gas from biomass usually has a low hydrogen-to-carbon (H/C) ratio, whereas syn-gas from natural gas has a very high H/C ratio. The aim of the syn-gas conditioning step is to produce syn-gas that has at least twice as many H_2 molecules as CO molecules. The optimal ratio of H_2 molecules to CO molecules depends on the initial syn-gas composition, as well as the availability of H_2. After conditioning, the syn-gas is converted into methanol by a catalytic process based on copper oxide, zinc oxide or chromium oxide catalysts. Distillation is used to remove the water generated during methanol synthesis. Oxygen is typically produced via cryogenic air separation (large capacities that are well-suited for methanol production), pressure swing adsorption (PSA, small- to mid-size capacity), or electrolysis. The technologies used in the production of methanol from biomass are relatively well known since they are similar to the coal gasification technology, which has been applied for a long time. However, making biomass gasification cost-competitive has proven difficult.

EFFICIENCY AND EMISSIONS

The production of bio-methanol will reduce the need for fossil fuel and nuclear energy consumption and will reduce greenhouse gas (GHG) emissions. The energy efficiency of methanol production from natural gas ranges from about 60-70 per cent. For methanol production from natural gas, petroleum products and coal, the process energy ranges between 29-37 gigajoule (GJ) per tonne, including feedstock use, depending on the feedstock mix and regional variations in energy efficiency. For methanol from biomass and coal, the energy efficiency is estimated to be lower, between 50-60 per cent. In general, the overall energy efficiency of a bio-methanol plant will depend on which process steps are included, whether electricity or heat are co-produced and on the size of the plant. Estimates of CO_2 emissions from bio-methanol production in the literature also vary widely based on different assumptions. Majer and Grongroft, 2010 estimated that in Germany the production based on short rotation coppice (0.64 kg CO_2 eq/kg bio-methanol) and forest residues (0.56 kg CO_2 eq/kg bio-methanol) can lower cradle-to-factory-gate GHG emissions by 24 and 33 per cent, respectively, compared to methanol from natural gas (0.84 kg CO_2 eq/ kg methanol). In addition, Dowaki and Genchi, 2009 estimate that Japanese wood-based bio-methanol production can achieve CO_2 emission reductions of 24-40 per cent compared to natural gas.

PERFORMANCE AND SUSTAINABILITY

Performance of bio-methanol plants depends on many factors, such as the plant set-up (e.g. feedstock, co-products, technology) and local conditions (e.g. availability of feedstock or renewable electricity). Assessing real life performance is difficult as only a limited number of commercial plants are currently in operation. An option which could be economical would be to mix renewable and fossil feed-stocks (co-feeding). This can gradually make methanol production environment friendly and increase



Overview of Methanol production process

the expertise in biomass-based methanol production.

Another option to increase economic and environmental performance of bio-methanol production is the co-production of other forms of energy or chemicals. For example, co-generation of electricity and heat for district heating are often included in plant designs as they can increase energy efficiency and revenues. Chemicals co-production can also improve economics and energy efficiency. Bio-methanol can be co-produced along with hydrogen, bio-ethanol and urea.

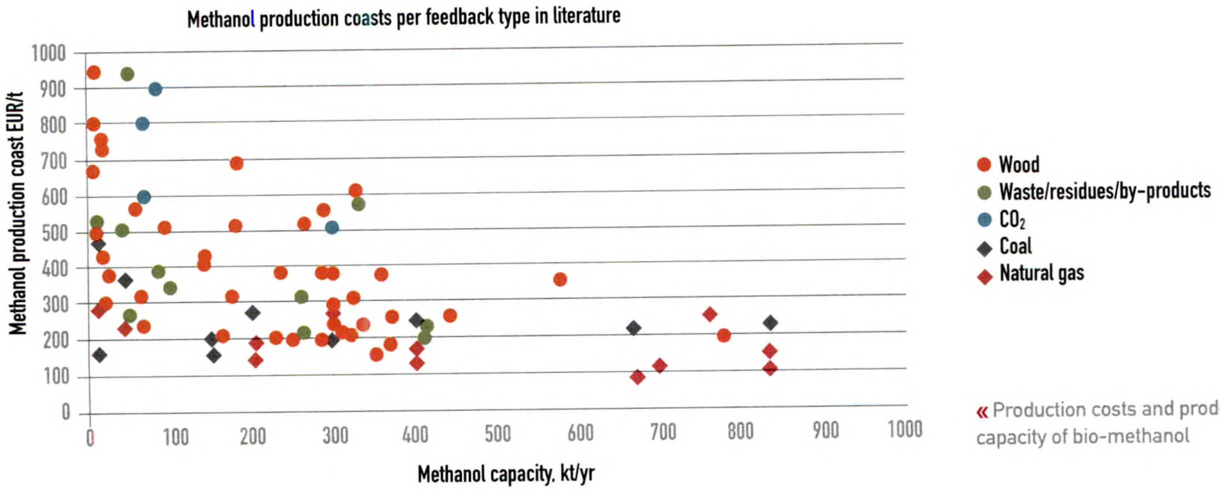
Bio-methanol can be produced from virgin or waste biomass, non-biogenic waste streams or even CO_2 from flue gases.

CURRENT COSTS AND COST PROJECTIONS

The production costs of bio-methanol are also highly sensitive to local conditions. Key factors that influence the currently available estimates are feedstock types and prices, electricity generation fuel mix and prices, scale of production capacity, technology choice and investment costs and the desired grade of the final product. Electrolysis requires a lot of electricity, but if the price of electricity is very low, a bio-methanol facility using electrolysis can become an economically attractive option. The costs of methanol production from fossil fuels for natural gas and coal respectively range from 75-250 EURO/t for natural gas and from 150-300 EURO/t for coal. The cost of wood-based bio-methanol production is estimated to range from 160 to 940 EURO/t. The capital cost per unit of capacity is at least 3.4 times higher than the capital cost of plants based on natural gas. A bio-methanol production facility based on CO_2 is estimated to be about 15 times as expensive as the most economical natural gas-based facility. Larger plants (e.g. 30-40 kt/yr capacity) are estimated to have a significantly lower cost per unit of capacity. Overall, based on biochemical conversion, for the same energy output, bio-methanol plants are about 1.8 times more expensive than bio-ethanol facilities.

POTENTIAL AND BARRIERS

From a supply potential perspective, the current production of waste and by-products amounts to about 3,550 and 39 PJ/yr, respectively. From a technical point of view, the biomass gasification is the most challenging step. Different gasifier



« Production costs and production capacity of bio-methanol

concepts offer different performance and it is unclear which one is best suited to biomass. The gasification efficiency is expected to improve by 5-10 per cent through technology innovation and this could remove one of the barriers to bio-methanol production. Another barrier to bio-methanol commercialization is the relatively high capital cost. This is in part due to the fact that the crude syn-gas produced from biomass is more contaminated compared to production from natural gas and therefore requires additional cleaning technologies. The increased cleaning capabilities of bio-methanol facilities also allow for a greater range of feedstock inputs. This makes bio-methanol facilities suitable for the gasification of municipal solid waste (MSW). As MSW landfill disposal is costly and environmentally questionable, recycling MSW in industrial processes could generate additional income and compensate for high capital costs. Natural gas prices could also impact the growth of bio-methanol production. Removing subsidies on fossil fuels, as recently recommended by the OECD, could help close the price gap between methanol from natural gas and bio-methanol. Producing bio-methanol at a similar capacity will be challenging because of technical and logistical problems in gathering, storing and handling sufficient amounts of biomass feed-stock. Co-supply facilities using biomass and by-products (with no seasonal availability variation), as well as fossil fuel sources, could help improve the overall economics of the process. The market development of bio-methanol will also depend on the demand for biomass for other uses (e.g. for power generation and biofuels). Policies to promote the use of bio-based chemicals and materials need to look at the entire life cycle of CO_2 emissions. Present policies only take the direct emissions from chemical production processes into account. Therefore, a policy framework which fully credits the environmental advantages of bio-based materials needs to be established. Such a system could make carbon tax systems more effective in promoting the production of bio-based materials. Policies could also include eco-labeling of bio-based chemicals, information campaigns and subsidies for producers. ✪

Inputs from IEA-ETSAP and IRENA Technology Brief E21 – 2013

INTERESTING FACTS

- Between 500 to 900 A.D. windmills were developed in Persia, they were used for the automation of grinding grain and pumping water.
- Wind energy was used by the Egyptians more than 5000 years ago for sailing ships on the River Nile.
- Hawaii houses the largest wind turbine in the world. It has rotors that are the entire length of a football field. The turbine stands at 20 storeys high.
- China tops the charts for installed wind power capacity in Asia as well as the world.
- The Indian Wind Energy Association has estimated that with the current level of technology, the 'on-shore' potential for utilisation of wind energy for electricity generation is of the order of 102 GW.

IRON-BASED CATALYST DEVELOPED FOR HYDROGEN FUEL CELL

Scientists at the Pacific Northwest National Laboratory have developed the first iron-based catalyst that can convert hydrogen directly to electricity for more affordable fuel cells.

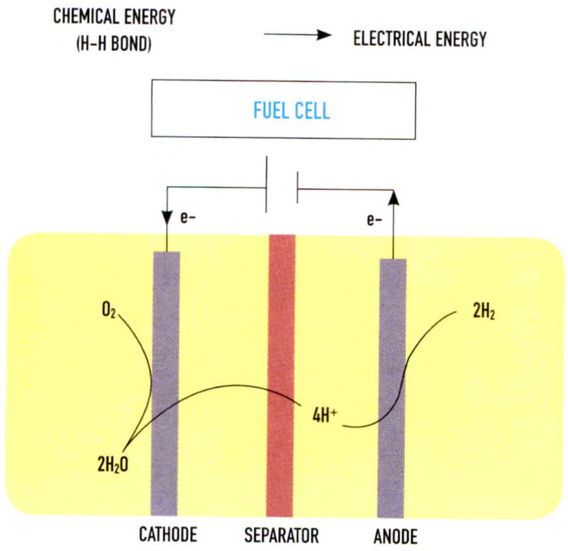
Fuel cells generate electricity out of hydrogen gas by triggering a chemical reaction that breaks the bond between two hydrogen molecules, releasing electrons to create an electrical current.

In most fuel cells, the catalyst used to trigger the necessary reaction is platinum or platinum-based. "A drawback with today's fuel cells is that the platinum they use is more than a thousand times more expensive than iron," said chemist R. Morris Bullock, who leads the research. Mr. Bullock's team at the Center for Molecular Electrocatalysis has been developing catalysts that use cheaper metals such as nickel and iron. Hydrogen when passed in a fuel cell generates an electrical current. A new iron-based catalyst might help make those fuel cells less expensive

Along with chemists Tianbiao Liu and Dan DuBois, Mr. Bullock developed a catalyst based on the molecule hydrogenase which uses iron to split hydrogen.

In order to get the results they wanted, the catalyst has to be able to split the hydrogen atom into all of its parts.

One hydrogen molecule is made up of two protons and two electrons and the catalyst would need to separate the protons, sending it away to be caught by a molecule called a proton acceptor. In a fuel cell, this acceptor would be oxygen. Once the protons are removed, the electrons would move on to the fuel cells electrodes, creating an electric current for power. The team determined the shape and size of the catalyst and also tested different proton acceptors. With iron in the middle, arms hanging like pendants around the edges, it draws out the protons. The team then measured how fast the catalyst could split molecular hydrogen. Their best time was about two molecules per second, thousands of times faster than the closest, non-electricity making iron-based competitor. The catalyst could also efficiently produce energy at around 160 to 220 millivolts, similar in efficiency to most commercially available catalysts. The team will be continuing to test the catalyst, figuring out how to make the reactions faster and determine the best conditions under which it performs. The work was supported by the Department of Energy, Office of Science, USA. ❂



A new iron-based catalyst might help make fuel cells less expensive

Courtesy- Eco Seed, http://www.ecoseed.org

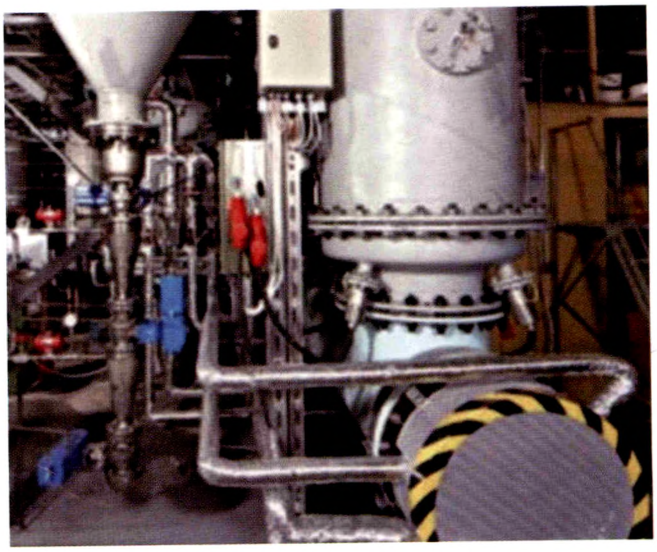
FOREST RESIDUES TO BIOFUEL THROUGH GASIFICATION

A new technology developed by VTT Technical Research Centre of Finland allows the transfer of more than half the energy of wood raw materials to the end-product. The technology is considered ready for the construction of a commercial-scale production plant in Europe.

According to the new research results of the VTT Technical Research Centre of Finland, lignocellulosic biomass can be used in the production of high-quality biofuels for the price of less than one euro per litre. A new technology developed in Finland allows the transfer of more than half the energy of wood raw materials to the end-product. The technology is considered ready for the construction of a commercial-scale production plant in Europe.

VTT has assessed the techno-economics of the production of renewable liquid transportation fuels from forest residues. The case studies focused on the production of four biofuels using a method based on pressurised fluidised-bed gasification. The fuels studied were methanol, dimethyl ether (DME), Fischer-Tropsch liquids and synthetic gasoline. The results show that the production of renewable biofuels from lignocellulosic biomass, mainly bark and forestry residues, could achieve an energy efficiency of 50-67 per cent, depending on the end-product and process conditions. Should the thermal energy produced as a by-product be exploited for district heat or industrial steam, for example, the overall efficiency from biomass to saleable energy products could reach 74-80 per cent.

Based on the case studies, the research scientists estimated that once commercialised the technology can be used to produce liquid transportation fuel at the cost of 58-78 EURO/MWh. Converted into gasoline-equivalent price per litre, the estimated production cost would be 0.5-0.7 EURO/litre. The price of renewable solutions would thus be on a level with the current pre-tax price of fossil transportation fuels, and cheaper than existing imported biofuels. Each case study design was based on a BTL plant with 300 MW capacity, the equivalent of a large district heating power plant. A biorefinery of this size could produce liquid transportation fuel for about 150000 cars. The EU has set a target of 10 per cent renewable energy content for the transportation sector by 2020. For Finland, the target is 20 per cent. After long-term development work, the technical functionality of the production process was verified through extensive testing at VTT test rigs as well as industrial piloting in Finland and in the US. The technology is now ready for its first commercial-scale demonstration. However, the first wave of these ground-breaking production plants requires significant public venture capital investment, for which planning has consequently been initiated at both Finnish and EU level.



≈ VTT has assessed the techno-economics of the production of renewable liquid transportation fuels from forest residues.

Inputs - Science Daily, www.sciencedaily.com

Solar passive design, University of Horticulture and Forestry, Solan, Himachal Pradesh

HIMURJA SETS UP STATE LEVEL RENEWABLE ENERGY PARK

HIMURJA has set up an energy park in Himachal Pradesh. This energy park provides a forum to general public where they can understand different renewable energy applications by operating working models of renewable energy devices.

The Ministry of New and Renewable Energy (MNRE), Government of India under its special area demonstration project scheme (SADP) provides Central Financial Assistance for the setting up of state level energy parks. Energy parks provide a forum to the general public where they can understand the use of different forms of renewables by operating working models of renewable energy devices/exhibits. For setting up of a state level energy park MNRE, provides central financial assistance (CFA) up to 1.00 crore. The energy park needs to fulfill the following objectives:

- To impart awareness to public, students, visitors and beneficiaries about the use of renewable energy, its advantages and its relation with the environment.
- To demonstrate non-polluting renewable based transportation system by introducing solar powered cars and battery operated bicycles.
- Demonstration of the technical parts of various renewable energy devices to educate people on the subject.
- To provide a forum for the children to have fun with experimentation with renewable energy devices.
- To fulfill partial energy requirement of the park from renewable energy sources i.e. solar, hydro, bio-mass and wind energy.

The MNRE has sanctioned two state level energy parks in Himachal Pradesh, out of which one park was set up by

» **Children's corner at the Energy Park**, Solan, Himachal Pradesh

HIMURJA at Dr. Y. S. Parmar University of Horticulture and Forestry, Solan, during March 2013. Another energy park was set up at National Institute of Technology (NIT) Hamirpur is in an advanced stage and is likely to be completed by October, 2013.

Following are the main features of the energy parks :

1. **Children's corner:** In the children's corners computer based solar energy and wind energy games have already been set up for recreation. In the learning through fun, the exhibits are based on paddle power, walk and generate electricity through rolling drum, energy slip and power generating marry-go-round to demonstrate the phenomenon of conversion of mechanical energy into the electrical energy. Five solar powered cars and bicycles are also available in the Park for the recreations of children.
2. **Solar pavilion**: A solar photovoltaic plant of 5 KW capacity has been installed in the energy park to meet the power requirement of buildings and power requirement for the operation of the working models of renewable energy devices. The exhibits/devices such as different models of solar cookers, solar water heating system, solar lights, home lights, solar lantern, solar drier and solar still etc. are displayed for providing awareness and use of different forms of solar energy in our day to day life.
3. **Bio-energy pavilion**: Biomass is one of the interesting and very promising technology to substitute conventional energy source. Today due to rise of fuel prices and environmental issues, biomass has become an important source of renewable energy for securing sustainable energy and for tackling climate change. To make people understand the concepts of biomass fuel and energy, a working model of 5 KW biomass gasifier plant and biogas plant of 10 cum capacity has been set up in the Park.
4. **Water pavilion**: Water is the most freely available natural element on this planet, and is also one of the most potential sources of non-conventional energy. Gravity causes water to flow downwards and this downward motion of water contains kinetic energy, which can be converted into mechanical energy, and then from mechanical energy into electrical energy. Different working models of hydro power turbines operating under different heads are displayed in the water pavilion. The water power exhibits, therefore, assume a significant role in the energy education park.
5. **Wind energy pavilion**: The exhibit will display different types of windmills both vertical and horizontal. All the windmills shall be operational through artificially created wind from a blower.
6. **Solar passive heating**: Solar energy is a radiant heat source that causes natural processes upon which all life depends. The basic natural processes that are used in passive solar energy are the thermal energy flows associated with radiation, conduction, and natural convection. When sunlight strikes a building, the building materials can reflect, transmit, or absorb the solar radiation which helps to heat up the building ✪

Inputs from Panna Lal Sharma, Assistant Public Relation Officer, HIMURJA, Himachal Pradesh.
Email-plsharmapro@gmail.com

MAKE A BATTERY FROM A LEMON

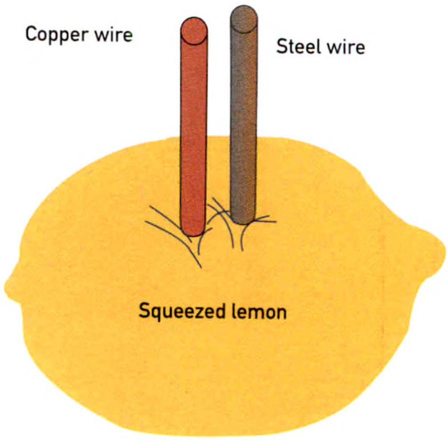
MATERIALS AND EQUIPMENT

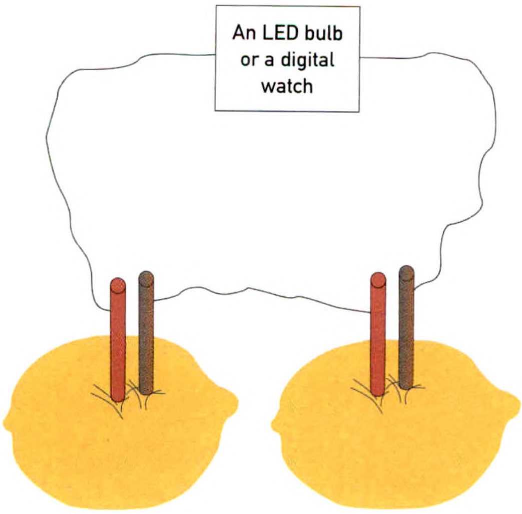
- 18-gauge copper wire
- 18-gauge steel wire
- Wire clippers
- Steel paper clip
- Sheet of coarse sandpaper
- Lemon
- Help from an older friend or an adult

THE EXPERIMENT

- Have your older friend or an adult strip 2 inches of insulation off the copper wire. Clip the 2 inches of bare wire with the clippers.
- Straighten out the paper clip and cut about 2 inches of the straightened steel wire
- Use sandpaper to smooth any rough spots on the ends of the wire and paper clip
- Squeeze the lemon gently with your hands. But don't rupture the lemon's skin.
- Rolling it on a table with a little pressure works great.
- Push the pieces of the paper clip and the wire into the lemon so they are as close together as you can get them without touching.
- Moisten your tongue with saliva. Touch the tip of your wet tongue to the free ends of the two wires.

You should be able to feel a slight tingle on the tip of your tongue and taste something metallic.





WHAT WILL YOU DISCOVER?

- The lemon battery is called a voltaic battery, which changes chemical energy into electrical energy.
- The battery is made up of two different metals (the steel paper clip and the copper wire). These are called electrodes, which are the parts of a battery where electric current enters or leaves the battery. The electrodes are placed in a liquid containing an electrolyte, which is a solution that can conduct electricity.
- In a solution of water and an electrolyte, like the acid in the lemon, an excess of electrons collects on one end of the electrodes. At the same time, electrons are lost from the other electrode.
- Touching the electrodes to your tongue closes the circuit and allows a small electric current to flow. A single lemon produces about 7/10 of a volt of electricity.
- If you connected two lemons together, you can power an inexpensive digital watch (uses about 1.5 volts). (Use a length of thin, flexible wire to connect the steel wire of one lemon to the copper wire of the other lemon. Then attach thin wires from the other two wires in the lemons to where a battery's positive and negative poles connect to power the watch.)
- The tingle felt in your tongue and the metallic taste is due to the movement of electrons through the saliva on your tongue.

Inputs from: energyquest.ca.gov

GREEN PRODUCTS

Premium Flooded Batteries

Renewable energy applications operate under challenging conditions such as fluctuating or extreme temperatures, remote locations and the intermittent nature of solar and wind power generation. Designed with a 10-year battery life, Trojan Battery's Premium Line of flooded deep-cycle batteries are specifically engineered to withstand the rigorous conditions of renewable energy applications. The Premium Line incorporates advanced battery features such as Trojan's DuraGrid™, MaxGuard® XL separator and Alpha Plus® Paste technologies that provide superior performance, rugged durability and exceptionally long life. The product strategy is focused on the objective of manufacturing the highest quality battery available in the industry and is tested to IEC standards.

Source - www.trojanbatteryre.com

Solar Powered Fridge / Freezer

Green Energy Innovations offer an entire line of solar powered refrigerators. The DC powered solar refrigerator can operate on as little as 72W of power and the freezer required just 60W of power to keep it running. All units can operate with just one solar panel and a single battery and can operate on either 12V or 24V depending on the battery configuration. The units can operate with an AC power source with an optional AC adapter and the AC/ DC optional switch. It is ideally suited for customers who are not connected to an electric grid or those who experience regular power outages. This DC powered refrigerator will keep food safe and fresh even when the power goes out.

Source : www.geinnovations.net

Website

New Website Shows Location of Subsea Cables, Renewable Energy Structures

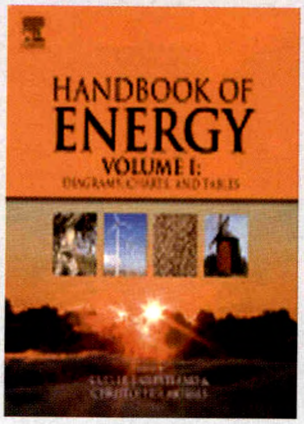
www.kis-orca.eu

The website offering accurate, up to date information to fishermen on the location of subsea cables and renewable energy structures is the latest development in a long-running collaboration between the Kingfisher Information Service of Seafish and Subsea Cables UK. Renewable UK has been welcomed into the latest phase of this project, which has made possible the inclusion of wind farm and renewable energy data. Information on the location of renewable structures such as wind farms, is a new addition to the Kingfisher dataset that is already provided by Kingfisher and made available at zero cost to fishermen.

Kenya Launches Renewable Energy Portal

www.renewableenergy.go.ke/

The web-based portal is a one-stop window providing information on the licensing and regulatory requirements for renewable energy projects development in Kenya. Development of the portal has been a participatory process cognizant of the existing information outlets managed by other government agencies. The portal contains information on all the licensing requirements from the different issuing agencies as well as agencies that provide associated information on RE projects and include prerequisites for application, fees and charges, expected processing time, contact persons and office location, RE electricity tariff structures, status of the RE sector, overview of RE resources, among others.

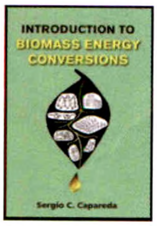


Handbook of Energy

By **Cutler J. Cleveland and Christopher Morris**

Hardcover: 1034 pages
Cost: 124. 15 USD
Publisher: Elsevier Science; 1 edition
ISBN-10: 008046405X
ISBN-13: 978-0080464053

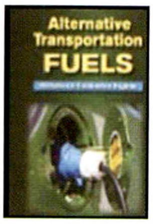
The Handbook of Energy provides comprehensive, organized coverage on all the phases of energy and its role in society, including its social, economic, political, historical, and environmental aspects. While there is a wealth of information about energy available, it is spread across many books, journals, and websites and it tends to target either a particular form of energy or a specific audience. The book provides a central repository of information that meets diverse user communities. It focuses on tabular, graphic, and list-based information in a schematic format. Individuals and researchers at all educational levels will find the book to be a valuable addition to their personal libraries.



Introduction to Biomass Energy Conversions

By: **Sergio Capareda**

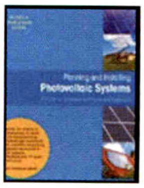
Hardcover: 645 pages
Cost: 129.95 USD
Publisher: CRC Press-1 edition
ISBN-10: 1466513330
ISBN-13: 978-1466513334



Alternative Transportation Fuels: Utilisation in Combustion Engines

By: **M.K. Gajendra Babu, K. A. Subramanian**

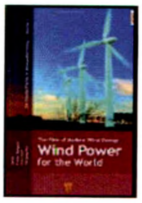
Hardcover: 464 pages
Cost: 111.15 USD
Publisher: CRC Press; 1 edition
ISBN-10: 1439872813
ISBN-13: 978-1439872819



Planning and Installing Photovoltaic Systems

By: **Deutsche Gesellschaft für Sonnenenergie (DGS)**

Paperback: 536 pages
Cost: 185.25 USD
Publisher: Routledge: 3 edition
ISBN-10: 184971343X
ISBN-13: 978-1849713436



Wind Power for the World: The Rise of Modern Wind Energy

By: **Preben Maegaard, Anna Krenz, Wolfgang Palz**

Hardcover: 676 pages
Cost: 63.81 USD
Publisher: Pan Stanford Publishing
ISBN-10: 9814364932
ISBN-13: 978-9814364935

In India

25 - 27 September 2013	World Renewable Energy Technology Congress & Expo (WRETC-2013), **Place**- New Delhi, **Organiser**- Energy and Environment Foundation, **Contact**- Punit Singh, (011) 22758149, **Website**- www.wretc.in
22-26 October 2013	Green Building Congress 2013, **Place**- CTC Complex, Hyderabad, **Organiser**- Confederation of Indian Industry, **Contact**- Shyam Chander Kunagaran, 91-40-44185 111, **Website**- www.cii.in
11 - 12 November 2013	The Intersolar India Conference, **Place**- Bombay, **Organiser**- Messe München International, **Contact**- Brijesh Nair, +91 22 4255 4707, **Website**- www.intersolar.in
19- 20 November 2013	Solar Energy Liveweek 2013, **Place**-Delhi, **Organiser**- Liveweek Business, **Contact**-Ms. Mugdha, 91-98110-16199, **Website**- www.sustainableenergyliveweek.com
27-29 November 2013	International Congress on Renewable Energy, Place- Bhubaneswar, Odisha, Organiser Solar Energy Society of India, Contact- Jagat S. Jawa, 91-11-65649864, Website- www.icoreindia.org

In Other Countries

9 - 12 October 2013	International Congress on Energy Efficiency and Energy Related Materials (ENEFM), **Place**- Antalya, Turkey, **Organiser**- Congress Secretariat, Tura Turizm, **Contact**- A. Yavuz Oral, +90-212 241 27- 00, **Website**- www.enefm.org
14 - 15 October 2013	Offshore Wind Construction, Installation and Commissioning Conference, **Place**- Hamburg, Germany, **Organiser**- Wind Energy Update, **Contact**- Jon Harman, +44 (0) 207 375 7577, **Website**- www.windenergyupdate.com
24 - 25 October 2013	Local Renewables Freiburg 2013, **Place**- Freiburg, Germany, **Organiser**- ICLEI European Secretariat, **Contact**- Tu My Tran, +49-761/368 92 20 **Website**- - www.local-renewables-conference.org
24 - 25 October 2013	Renewable Energy World Conference & Expo North America, **Place**-Orlando, Florida, **Organiser**- Pennwell, **Contact**-Lizzie Cohlmia, 918-832-9298, **Website**- www.pennwell.com
12—13 November 2013	CSP Today Sevilla 2013, **Place**- Seville, Spain, **Organiser**-CSP Today, **Contact**- Mercedes Galíndez, +44 (0) 20 7422 4348, **Website**- www.csptoday.com

RENEWABLE ENERGY AT A GLANCE

Cumulative deployment of various renewable energy systems/ devices in the country as on 31/08/2013

RENEWABLE ENERGY PROGRAMME/ SYSTEMS	TARGET FOR 2013-14	DEPLOYMENT DURING JULY, 2013	TOTAL DEPLOYMENT IN 2013-14	CUMULATIVE ACHIEVEMENT UP TO 31.07.2013
I. POWER FROM RENEWABLES				
A. GRID-INTERACTIVE POWER (CAPACITIES IN MW)				
Wind Power	2500	118.00	726.20	19779.15
Small Hydro Power	300	5.00	79.50	3711.75
Biomass Power	105	-	-	1264.80
Bagasse Cogeneration	300	-	-	2337.43
Waste to Power-Urban-Industrial	20	3.00	3.00	99.08
Solar Power	1100	129.84	284.00	1968.84
Total	4325	255.84	1092.70	29161.05
II. OFF-GRID/CAPTIVE POWER (CAPACITIES IN MWEQ)				
Wind Power-Urban Industrial	10.00			115.57
Biomass (non-bagasse) Cogeneration	80.00	-	15.69	486.84
Biomass Gasifiers-Rural	1.00	0.032	0.132	16.924
-Industrial	9.00	0.50	1.80	143.38
Aero-Genrators/Hybrid systems	1.00	-	0.03	2.14
SPV Systems (>1kW)	40.00	-	7.19	131.86
Water mills/micro hydel	500 Nos.	-	-	10.65 (2131 nos)
Bio-gas based energy system	2	-	-	-
Total	143.00	0.532	24.84	907.36
II. REMOTE VILLAGE ELECTRIFICATION				
No. of Remote Village/Hamlets provided with RE Systems	-	-	-	-
III. OTHER RENEWABLE ENERGY SYSTEMS				
Family Biogas Plants (No. in lakhs)	1.10	0.06	0.06	46.55
Solar Water Heating-Coll. Areas (Million m^2)	0.60	0.09	0.16	7.16

Volume 7 | Issue 2 & 3 | December 2013

सत्यमेव जयते

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Renewable Energy

Akshay Urja

www.mnre.gov.in

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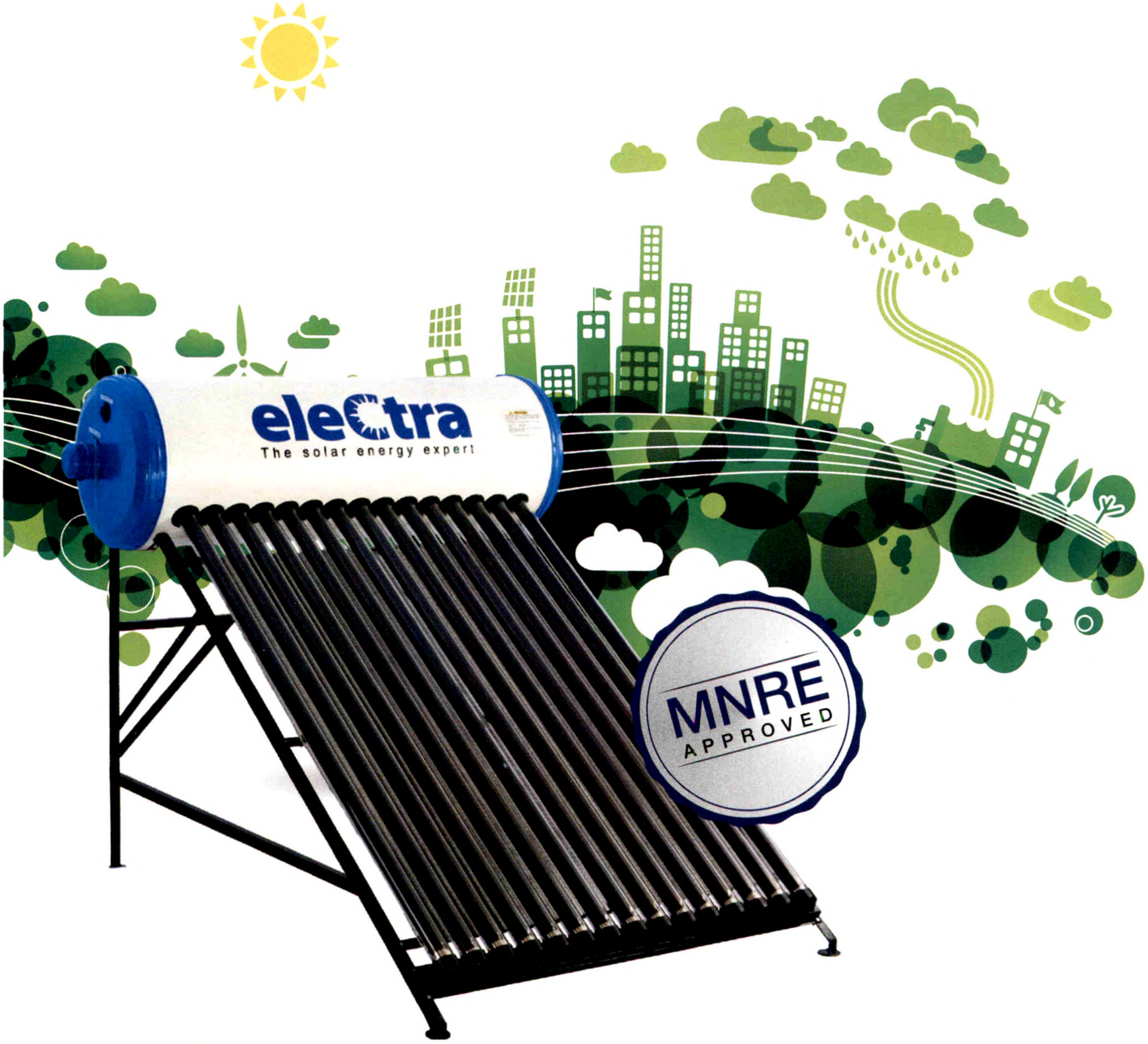
The solar energy expert

Solar Water Heating Solutions



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Akshay Urja

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Disclaimer: The views expressed by authors including those of the editor in this newsletter are not necessarily the views of the MNRE.

From the Editor's Desk

Dear Readers,

The Brundtlant Commission Report 'Our Common Future' published by the World Commission on Environment and Development (WCED) in 1987 released by the United Nations defines sustainable development as "the development that meets the needs of the present without compromising the ability of future generations to meets their own needs". Since then, sustainable development has been defined in many fora and renewable energy qualifies as a contributory factor towards sustainable development. With about 30,000 MWp installed capacity of grid interactive renewable power in the country, India has been moving towards sustainable development in power generation. In addition the target set under the National Action Plan on Climate Change in 2008, to increase the share of renewable energy in the country's energy mix to 15 per cent by 2020, underlines the country's commitment towards sustainable development.

The supply of renewable electricity in the rural part of India in a decentralized manner has been found to be a sustainable and economic solution to the energy crisis. Immediate steps are required by all concerned parties, particularly the states, to replace kerosene based lamps with solar lighting systems in a 'mission mode'. The time has come to get rid of the inefficient, polluting and out-dated kerosene lamps. This will not only provide quality light but will also save foreign exchange and Government subsidy, besides being environmentally benign.

The solar water pump is another device which can provide a solution not only for irrigation, but it can also help in energizing the area with solar lights, and be used for other energy requirements in the area and households. Rajasthan has shown the way by implementing a large solar water pump programme, which is evident from the article by Shri Dinesh Goyal in the present issue. Purification and bottling of biogas, and its comprehensive utilisation has been well presented by Shri Bamboriya in his article in this issue.

I would like to thank our readers for their continuous support, and I seek their valuable suggestions to make Akshay Urja useful and informative. I wish a very happy and prosperous 2014 to all.

Happy reading.

अक्षय ऊर्जा से देश विकास

ARUN K TRIPATHI
<aktripathi@nic.in>

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Letters to the Editor

Greetings from the Manav Rachna International University! We are in receipt of a copy of your publication 'Akshay Urja'. We have found the publication very useful for our students, researchers and academic community. We request you to please add our name to your mailing list for both the editions in Hindi as well as in English.

The Central Library
MRI University, Faridabad.

I am a Professor in the Commerce Department in Shivaji College, Akola, Maharashtra. I have a great interest in solar energy. I found 'Akshay Urja' very useful for us. Kindly send your bi-monthly magazine to us regularly.

Dr. Ulhas Medshikar,
Jyotinagar, Maharashtra.

The Renewable Energy, 'Akshay Urja' newsletter is a good source of regular information, achievements, technology, developments on the renewable energy. I appreciate your good effort.

U. K. Rastogi,
Meeurut, Uttar Pradesh.

With due respect and the subject cited above, we on behalf of P.B. Tent and Traders, we want to acknowledge that we have been receiving the newsletter 'Akshay Urja' for a long period. We really, appreciate good work and request you to continue our subscription for the next year.

Bineet Kumar Modi,
P. B. Tent & Traders, Assam

विगत् कई वर्षों से मैं अक्षय ऊर्जा का नियमित पाठक हूँ। देश के ग्राम्य जीवन को समर्पित यह पत्रिका बहुत उपयोगी है। पत्रिका से ज्ञात होता है कि प्राकृतिक संसाधनों को बचाने के लिए हमें ऊर्जा के नए स्रोतों का उपयोग करना चाहिए। पत्रिका से सौर ऊर्जा, पवन ऊर्जा और जैविक ऊर्जा के क्षेत्र में मंत्रालय द्वारा किए गए नए–नए शोध कार्य और अध्ययनों के बारे में जानकारी मिलती है। मैं अपने छोटे से गांव का प्रधान था। इस पत्रिका के माध्यम से इसमें दी हुई जानकारी मैं अपने गाँव वासियों में बांटता हूँ। आगे हमें यह जानकारी मिलते रहे इसके लिए आपका आभारी रहूंगा।

मेहरबान सिंह (पूर्व ग्राम प्रधान)
पौड़ी गढ़वाल, उत्तराखण्ड

'अक्षय ऊर्जा' पत्रिका के 50वें अंक के सफल प्रकाशन के लिए आपको बहुत–बहुत बधाई और हार्दिक शुभकामनाएँ। ऊर्जा के क्षेत्र में आपके मंत्रालय द्वारा यह प्रकाशन बहुत प्रशंसनीय एवं सराहनीय है, जिससे हमें अनेक प्रकार की रोचक एवं महत्वपूर्ण जानकारियाँ प्राप्त होती रहती हैं। आज के ग्लोबल वार्मिंग के खतरे को देखते हुए और पर्यावरण को बचाने के लिए इस पत्रिका में बहुत सारे उपाय बताए जाते हैं। पत्रिका के माध्यम से हम न केवल पर्यावरण का संरक्षण और संवर्धन कर सकते हैं बल्कि अपनी आने वाली पीढ़ी को भी लाभान्वित करा सकते हैं। ''अक्षय ऊर्जा'' के माध्यम से सोलर एनर्जी, बायोमास, बायोगैस, पनचक्कियों और हरित भवन आदि के विषय में व्यापक जानकारी एवं ऊर्जा के अन्य स्रोतों से इनका तुलनात्मक अध्ययन करना आसान है। यह लाभकारी पत्रिका हमें इसी प्रकार मिलती रहे।

धर्मबीर सिंह
सोनीपत, हरियाणा

'अक्षय ऊर्जा' नामक द्विमासिक समाचार पत्रिका का अंक 5 और 6 मैंने देखा। हमें बहुत अच्छा लगा। हमारी संस्था श्री स्वामी समर्थ सार्वजनिक वाचनालय, महागांव, सोलापुर में मान्यता प्राप्त पुस्तकालय है। इस पुस्तकालय में हिन्दी और अंग्रेजी भाषा जानने वाले पाठक आते हैं। 'अक्षय ऊर्जा' समाचार पत्रिका पढ़कर लोग इसका प्रचार–प्रसार करते हैं।

सचिव/अध्यक्ष,
श्री स्वामी समर्थ सार्वजनिक वाचनालय,
सोलापुर, महाराष्ट्र

'अक्षय ऊर्जा' का 50वां अंक पढ़ा, अत्यधिक रोचक एवं ज्ञानवर्धक लगा। संपादक महोदय द्वारा लिखा आवरण लेख 'भारत में अक्षय ऊर्जा के तीन दशक' बहुत ही सागरर्भित है। जवाहरलाल नेहरू राष्ट्रीय सौर मिशन, और कृषि फुहारा एवं विद्युत–भंडारण आदि अनेक विषयों पर जानकारी प्राप्त की। पूर्वोत्तर राज्यों में नवीकरणीय ऊर्जा के क्षेत्र में सशक्तीकरण का पता चला। यदि एक वाक्य में कहा जाए कि नवीरकणीय ऊर्जा के क्षेत्र में यह समाचार पत्रिका मील का पत्थर है, तो अतिश्योक्ति नहीं होगा। मैं अपनी और अपनी पूरी टीम की ओर से 'अक्षय ऊर्जा' के सफल और निरंतर प्रकाशन के लिए हार्दिक शुभकामनाएं देता हूँ।

विक्रम सिंह,
जयपुर, राजस्थान

मैं दीपक गुप्ता, नव युग स्कूल, नई दिल्ली में कक्षा 11वीं का छात्र हूँ। मैं अपने पिता के माध्यम से अक्षय ऊर्जा पत्रिका को हमेशा पढ़ता हूँ। इसमें दिए गए ऊर्जा संरक्षण और ऊर्जा पैदा करने के नए–नए उपायों को पढ़ना मुझे बहुत अच्छा लगता है। गत् वर्ष मैंने अक्षय ऊर्जा से संबंधित एक मॉडल तैयार किया था, जिसे पूरे स्कूल में प्रथम पुरस्कार मिला था, मैं इसका श्रेय इस पत्रिका 'अक्षय ऊर्जा' को देना चाहता हूँ। यह पत्रिका हम सभी के लिए और भी उपयोगी सिद्ध हो ऐसी हमारी कामना है।

दीपक गुप्ता
एण्ड्रयूज़गंज, नई दिल्ली

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja will make every effort to make this newsletter highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in terms of content and presentation. **Editor: Akshay Urja**

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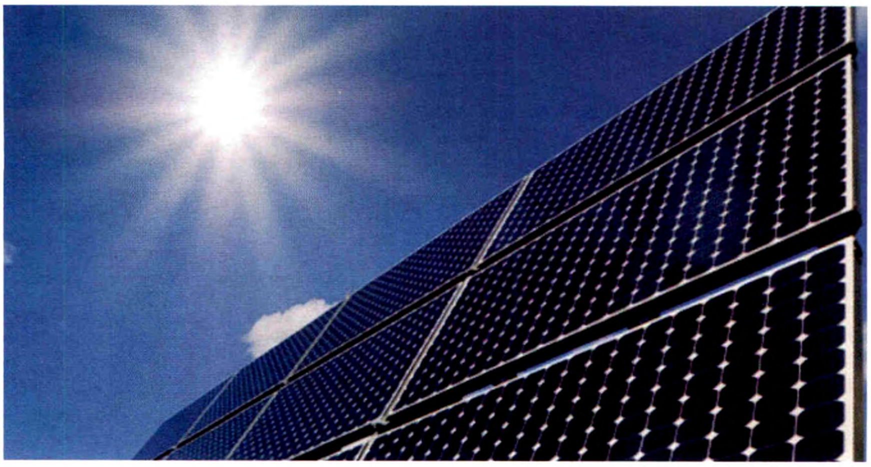
With 4000 solar systems in 2012-13, Rajasthan's solar pump programme is the largest in the world.

Biogas bottling plants are one of the most potent tools for mitigating climate change by preventing black carbon emission.

When power cuts started affecting academics, NIT Trichy decided to go the solar way.

RENEWABLE ENERGY NEWS



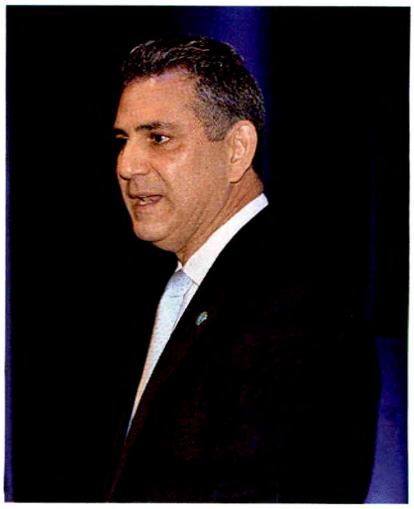
TARGET TO DEVELOP 10,000 MW POWER THROUGH SOLAR ENERGY BY 2017

Ministry of New and Renewable Energy has set a target of generation of 10,000 MW of power through solar energy by the year 2017. Addressing the Solar Power Developers Meet in the capital, the Minister for New and Renewable Energy Dr. Farooq Abdullah said that the Phase I of the Jawaharlal Nehru National Solar Mission (JNNSM) has been very successful wherein 1685 MW of solar power capacity was set up as against the target of 1100 MW. The Minister informed that large tracks of land have been identified in Rajasthan, Kargil and Ladakh which have immense potential of generation of solar power. Dr. Abdullah said that the main challenge was installing a transmission line in the areas of Kargil and Ladakh so that power could be evacuated to the other parts of the country. He also focused on the need for breakthrough in new research to ensure storage of solar energy for greater time period. The Minister highlighted the new initiatives for ensuring greater use of solar power in the government buildings and also said that the Ministry planned to use mobile towers in a way that they could generate power through solar and wind energy. On the occasion, the Minister gave awards to 13 organisations/ companies for having done commendable work in the first phase of the JNNSM.

Press Information Bureau, September 25, 2013

INDIA TOPS IN PRIORITY TO TAP RENEWABLE ENERGY POTENTIAL : BRYSON

John Bryson, former US secretary of Commerce and head of The Bryson Climate Initiative said that his top concern is to explore potential for adoption of renewable energy in India, China and Taiwan. At an interactive session on 'Renewable Energy and Climate Change' organized by Confederation of Indian Industry (CII) in Bangalore, he said that energy efficiency, role of green building concepts and larger penetrations of renewable energy will boost growth also. Aroon Raman, former chairman, CII Karnataka and managing director of Raman Fibre Science, Padu S Padmanaban, founder member,



CII-Green Business Centre and former programme director and senior energy advisor, USAID, India, K Krishan, chairman, CII task force on bio-energy and chairman, Envitec Biogas India and Syed Mohamed Beary, chairman, Indian Green Building Council, Bangalore and CMD and chairman, Bearys Group, provided valuable insights on the subject of energy efficiency and climate change vis-a-vis India.

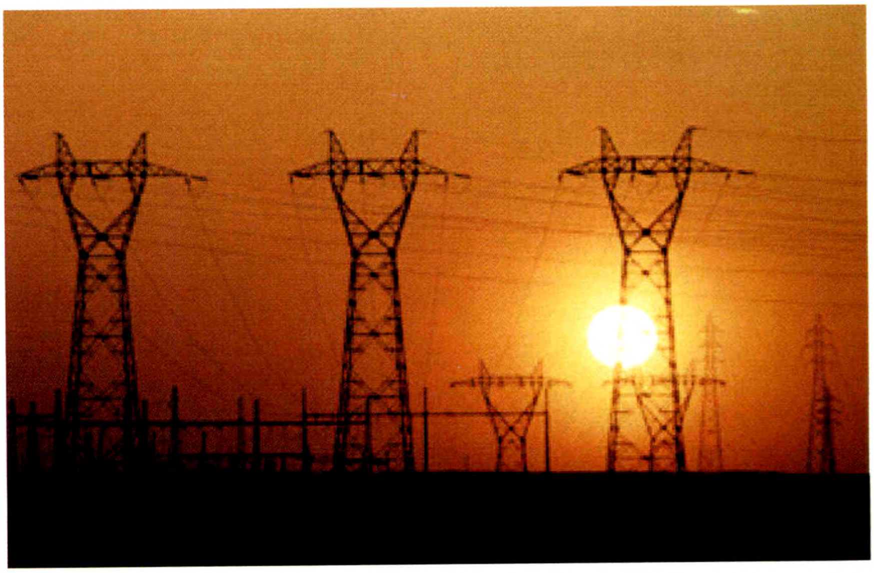
Aroon Raman said that the issues of climate change and renewable energy discussion involve best minds globally, however there is still much confusion on the ground. He said that currently there was a trade-off between the standard of living and climate change and similarly there was also a trade-off between sustainability and energy efficiency which needs to be addressed.

timesofindia.indiatimes.com, October 7, 2013

SETTING UP OF 750 MW OF GRID CONNECTED POWER CAPACITY UNDER JNNSM

The Cabinet Committee on Economic Affairs has approved the implementation of a scheme for setting up of 750 MW of grid-connected solar PV power projects under Batch-1 of Phase-II (2013-17) of the Jawaharlal Nehru National Solar Mission (JNNSM) with viability gap funding (VGF) support from the National Clean Energy Fund (NCEF).

The total VGF requirement for implementation of the scheme is estimated as Rs. 1,875 crore at the rate of Rs. 2.5 crore/ MW. The actual requirement will, however, depend on the bid prices. This VGF support is estimated to leverage private investment to the tune of Rs. 5000 crore in setting up of the projects.



The VGF scheme will facilitate setting up of the 750 MW grid connected solar power projects, in mainly the private sector on build, own and operate (BOO) basis at various locations, which will help supplement grid power generation in the country. These projects will also lead to an associated development of their surrounding areas with positive impact on the socio-economic conditions of the local population. The scheme will be implemented through the Solar Energy Corporation of India (SECI), a Section 25 company set up by the Ministry, in close association with NTPC Vidyut Vyapar Nigam Limited (NVVN). The power generated shall be purchased by SECI at a fixed levelised tariff of Rs.5.45 per kWh for 25 years and sold to willing state utilities/ discoms at a fixed tariff of Rs.5.50 per unit for 25 years. The selection of projects would be done through a process of open competitive bidding for their VGF requirement in order to enable them to supply the solar power to SECI at the fixed tariff of Rs.5.45 per kWh for 25 years.

Press Information Bureau, October 3, 2013

RENEWABLE ENERGY CERTIFICATES CONTINUE TO PILE

The September trading session at Indian Energy Exchange, featured trade of 38,195 N-Solar and 5,880 Solar RECs with supply far exceeding demand. In the non-solar segment, buy bids of 38,195 RECs and sell bids of 23,25,171 RECs were received against which 38,195 were cleared at Rs. 1,500 per REC. In the solar segment, buy bids of 5,880 RECs and sell bids of 37,028 RECs were received against which 5,880 RECs were cleared at Rs. 9,300 per REC. The trading session featured 658 participants of which 601 participated in non-solar segment while 159 participated in the solar segment.

On an overall basis, a total of 1969 participants are registered in the REC segment at IEX. Of this, 504 are eligible entities (RE generators), 1452 are obligated entities - discoms and open access consumers and captive generators and 13 are registered as voluntary entities.

ET Bureau, October 4, 2013

GREEN CORRIDOR TO SEE WIND AND SOLAR FARMS IN RAJASTHAN, TAMIL NADU

The government will set up wind and solar farms in Rajasthan and Tamil Nadu in the first phase of the Rs. 43,000-crore green energy corridors project that aims to add 30,000 MW to the national grid by 2020. The first phase of the Indo-German project is expected to cost Rs. 18,000 crore, of which Rs. 10,000 crore will be invested in two states, a senior official told ET. The initial funding for the project will be finalised by the month end and the first tranche of Rs. 2,500 crore is expected to come from Germany, the official added. Germany has committed technical and financial assistance of euro 1 billion for the green energy corridors under the Indo-German bilateral development cooperation programme.

"We have appointed a sub-group that will soon write to the finance ministry to seek the first tranche of Rs. 2,500 crore from Germany," the official, who did not wish to be named, said. "Meanwhile, it is also in talks with the PowerGrid and the National Cooperative Consumers Federation of India to fund the remaining part of the initial phase."

India aims to channel renewable energy from wind and solar projects into the national grid to help narrow the country's power deficit and reduce its dependence on coal. A massive grid failure last summer had left millions of people without electricity in several parts of the country.

The country has 27,541.71 MW of installed renewable energy capacity, excluding hydropower stations, but its integration with the national grid is difficult due to variations in supply and voltage. The green energy corridors will comprise of both inter-state and intra-state schemes for evacuation of power from wind and solar projects.

Integration of these projects with the national grid will require intra-state grid upgradation and inter-state networks that will be taken up by PowerGrid and the state utilities, respectively. The Power Grid Corporation of India, the central transmission utility, operates five grids—northern, western, southern, eastern and northeastern-—which together transmit nearly 1,29,980 MW during peak demand.

The Economic Times, October 9, 2013

INDIA OFFERS EXPERTISE TO CHILE FOR RENEWABLE ENERGY SECTOR

India has offered its support and expertise in setting up renewable energy projects for Chile, which is almost entirely dependent on imports for its energy needs. The offer was extended during a meeting between visiting Indian Minister of New and Renewable Energy Farooq Abdullah and Chile's Energy Minister Jorge Bunster. Both the countries have agreed to enhance their cooperation in the renewable energy sector.

"Abdullah offered India's support and expertise to Chile in setting up renewable projects. He offered the services of Indian experts and institutions...training of personnel and also preparation of projects for exploiting these technologies in Chile," an Indian government statement said here. The Indian minister also offered training slots in India to Chilean scientists, engineers and technicians through ITEC programme, while expressing India's desire to cooperate with the Latin American country in renewable energy, it added.

Abdullah is visiting Chile along with a high level delegation to explore greater opportunities for cooperation and collaboration between India and Chile.

He said India is planning to add over 30 GW of renewable energy to its energy mix in next 5 years, detailing the success of programmes on wind and solar energies.

Noting India's progress in the sector, Bunster said Chile is almost entirely dependent on imports for meeting its energy requirements and is looking to diversify by

introducing a large component of renewable energy in its energy mix. He said the Chilean government is looking to set up a 50 MW solar thermal generating capacity in the north of the country.
The Economic Times, September 13, 2013

OPEN JAIL TO BE POWERED BY THE SUN

The open jail at Nettukalthery in Tiruvananthapuram, Kerela, will take a huge stride forward in energy conservation and utilisation of non-conventional energy with the launch of a number of projects on its premises. The state home minister Thiruvanchoor Radhakrishnan will inaugurate the projects. Alexander Jacob, Director General of Prisons and Correctional Services, said the most important project was the solar one, comprising solar plants of 180 kW capacity, readied by ANERT at a cost of Rs.6.35 crore. A solar project at Thevancode State Institute of Correctional Administration (SICA), Poojappura, too would be launched. ANERT had installed plants of 146 kW capacity there at a cost of Rs.4.51 crore. These, Mr. Jacob said, were part of the entire Prisons Department moving towards use of solar energy, a first for any department in the country. The solar power scheme for the department had been initiated by former Additional Director General of Prisons K.P. Somarajan in 2008, for which the department had received Rs.25.26 crore. Apart from the huge savings in power bills — which ran into Rs.1,27,57,524 last year, solarisation would address security concerns during unscheduled power supply disruptions, Mr. Jacob said. Total solarisation would enable a 24-hour supply, along with a 12-hour backup.
The Hindu, October 7, 2013

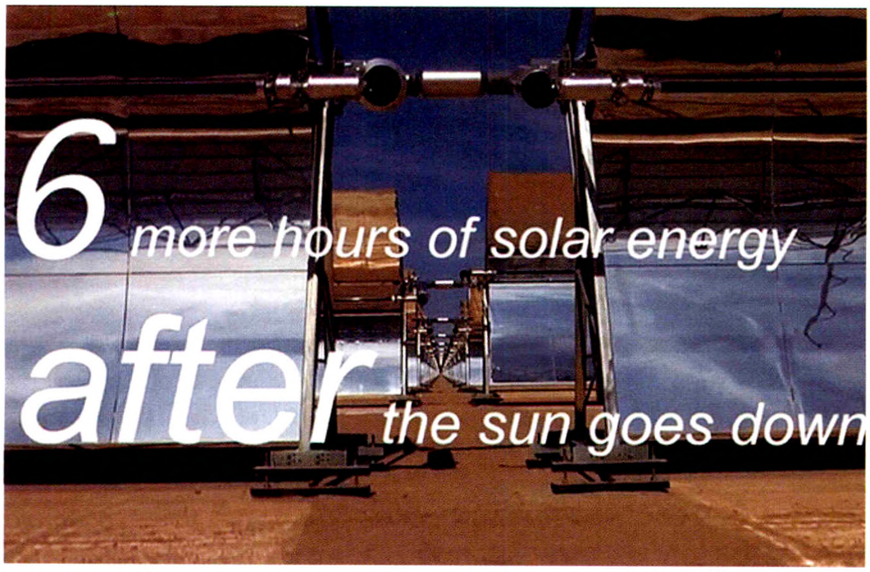
500 MILLION USD LOAN FOR RENEWABLE ENERGY TRANSMISSION PROJECT IN RAJASTHAN

The Asian Development Bank (ADB) will provide 500 million USD to build a power transmission system needed to deliver clean electricity from wind and solar power projects in Rajasthan in Northwest India to the state and national grids.

The Bhadla park in Western Rajasthan is the first solar park that is under development by the Rajasthan Renewable Energy Corporation, the state's renewable energy agency, to house solar PV and solar thermal projects and is part of Rajasthan's aim to reach about 8,000 MW of solar and wind generation capacity by 2018, largely from the private sector.

Work has already started on 75 megawatts of solar PV power at the Bhadla park after competitive bidding in early 2013 under the Rajasthan solar policy and a further 200 MW will be added annually starting 2014. The new power transmission system will involve about 1,850 km of transmission lines, mostly in western Rajasthan, three new 400 kilovolt substations and nine new 220 kilovolt grid substations. The funds will also be used to boost the transmission capacity of seven existing substations. Apart from serving the Bhadla park, the infrastructure supports solar and wind power developments in Western Rajasthan.

The funds comprise a 498 million USD multi-tranche financing facility including funds from the concessional Clean Technology Fund, and a further 2 million USD in technical assistance grant that finances infrastructure planning for the Bhadla park, transmission system studies and a community development plan to set up solar power electricity and clean water equipment for small communities. The government of Rajasthan and state transmission utilities will provide counterpart financing of about 300 million USD.
Source: Manikaran Power Ltd., Volume 108, September - October, 2013



280 MW SOLAR PLANT IN ARIZONA CAN PRODUCE POWER 6 HOURS AFTER THE SUN GOES DOWN

The Solana solar station in the Arizona desert is one of the first large-scale solar plants with thermal storage that allows it to keep producing power even when the sun doesn't shine, allowing it to better match output to peak demand. The three-square-mile facility near Gila Bend uses concentrated solar power (CSP) technology to heat up oil that is piped through the solar collectors (up to 735 degrees Fahrenheit). The heat transfer fluid is pumped to steam boilers, where it heats water to create steam. The steam drives two 140 MW turbines to produce electricity, much like a traditional power plant.

But what's special is that "in addition to creating steam, the heat transfer fluid is used to heat molten salt in tanks adjacent to the steam boilers. The thermal energy storage system includes six pairs of hot and cold tanks with a capacity of 125,000 metric tons of salt, and the molten salt is kept at a minimum temperature of 530 degrees Fahrenheit. When the sun goes down, the heat transfer fluid can be heated by the molten salt to create steam by running it through the tanks instead of the field of parabolic mirrors."

www.treehugger.com, October 14, 2013

GIANT MIRRORS REFLECT WINTER SUN INTO NORWEGIAN TOWN OF RJUKAN

Residents of the small Norwegian town of Rjukan have finally seen the light. Tucked in-between steep mountains, the town is normally shrouded in shadow for almost six months a year, with residents having to catch a cable car to the top of a nearby precipice to get a fix of midday vitamin D.

But on 30th October faint rays from the winter sun for the first time reached the town's market square, thanks to three giant mirrors placed on a mountain.

Cheering families, some on sun loungers, drinking cocktails and waving Norwegian flags, donned shades as the sun crept from behind a cloud to hit the mirrors and reflect down onto the faces of delighted children below.

TV footage of the event showed the centre of the crowded square light up a touch, but not as if hit by direct sunlight. Still, residents said the effect was noticeable.

"Before when it was a fine day, you would see that the sky was blue and you knew that the sun was shining. But you couldn't quite see it. It was very frustrating," said Karin Roe, from the local tourist office. "This feels warm. When there is no time to get to the top of the mountains on weekdays, it will be lovely to come out for an hour and feel this warmth on my face."

Like much of Scandinavia, Rjukan often is freezing throughout the winter, but on Wednesday it was 7° C.

www.theguardian.com, October 30, 2013

ETHIOPIA OPENS AFRICA'S BIGGEST WINDFARM

A windfarm billed as the biggest in sub-Saharan Africa has been opened by Ethiopia's prime minister, Hailemariam Desalegn, a potentially crucial step for the continent's renewable energy industry.

The 210 million euro Ashegoda windfarm consists of 84 hi-tech turbines towering above an arid region where villagers herd cattle and ride donkey-drawn carts as they have for generations.

The project, outside Mekelle in Tigray state, about 475 miles north of the capital, Addis Ababa, has a capacity of 120 MW and will produce about 400 million KWh a year. It was completed in phases over three and a half years and has produced 90 million KWh for the national grid.

The farm, inaugurated by Desalegn on Saturday, was supervised by German company Lahmeyer International and

implemented by France's Vergnet with French funding. But the Ethiopian government insisted there were also local spin-offs.

"The project has provided very important experience-sharing for Ethiopia's national companies, who have been involved in the construction of civil works such as geotechnical investigations, roads, turbine foundations, sub-station erection and electro-mechanical erection works," it said.

Ethiopia aims to become the region's leading producer of renewable energy. In the past two years it has built two smaller wind farms near Adama, south-east of Addis Ababa, with a capacity of 51MW each. It urgently needs new energy to fuel economic growth that has averaged more than 10 per cent over the past decade. Power cuts are still a regular occurrence in major cities and about half the country still has no access to electricity.

theguardian.com,
October 28, 2013

NUCLEAR POWER PLANT 'GOOD DEAL' FOR UK

Energy Secretary Ed Davey has defended building the UK's first nuclear station in a generation as "a very good deal for Britain".

French giant EDF will lead a consortium to build the Hinkley Point C plant in Somerset.

But environmentalists said the money could be better spent on renewables. The government estimates that energy bills will be £77 lower by 2030, but Davey could not guarantee this because of the "uncertainties".

When running at full capacity the new Hinkley plant is expected to generate around 7 per cent of the UK's electricity. The consortium and the government have agreed a "strike price" of £92.50 for every MW hour, almost twice the current wholesale cost of electricity. This will fall to £89.50 for every MW hour of energy if EDF Group goes ahead with plans to develop a new nuclear power station at Sizewell in Suffolk. Doing both would allow EDF to share costs across both projects.

"In terms of the per-MW hour price - which is what people are talking about today - the solar industry is asking for less than what the nuclear industry's getting," said Greenpeace's chief scientist Doug Parr.

www.bbc.co.uk,
October 21, 2013

SPAIN'S SUNSHINE TOLL: ROW OVER PROPOSED SOLAR TAX

"We will be the only country in the world charging for the use of the sun," says Jaume Serrasolses. "Strange things are happening in Spain. This is one of them."

Mr Serrasolses, the secretary of an association promoting the use of solar energy, SEBA, is referring to the government's proposal for a tax solely on those who generate their own electricity.

They would pay a backup toll for the power from their solar panels, in addition to the access toll paid by everyone who consumes electricity from the conventional grid. Although the tolls vary, if you pay an access toll of 0.053 euros per kWh, you could face a backup toll of 0.068 euros per kWh.

The new tax would extend the average time it would take for solar panels to pay for themselves from eight to 25 years, according to the solar lobby. The government says that with increasing "self-consumption", the income for conventional energy systems will decrease, but grid maintenance will cost the same.

"If I produce my own energy, but am connected to the grid, for backup in case my production fails, I have to contribute to the cost of the entire system," says Energy Secretary Alberto Nadal.

The government is hoping the energy reform will settle a debt of 26 billion euros, which has built up over years as a result of regulating energy costs and prices.

www:bbc.co.uk,
October 6, 2013

RAJASTHAN SOLAR WATER PUMP PROGRAMME

SUSTAINABLE FUTURE FOR FARMERS

With 4000 solar pumps installed in 2012-13, Rajasthan's solar pump programme is the largest in the world. The solar powered pumps are creating sustainable livelihoods in dry areas by integrating water harvesting and drip irrigation innovatively, increasing the resiliency of rural areas.

DINESH KUMAR GOYAL

^ Solar Panels

The state of Rajasthan has 10 per cent of India's land, 5 per cent of its population and only 1 per cent of its water resources—a disadvantage by a factor of ten for supply of irrigation water vs agriculture area. Acute water shortage, erratic rainfall and recurring droughts in every district have exacerbated the situation. Over 60 per cent of the population depends for livelihood on agriculture or horticulture, often marred by low productivity due to unreliable, inadequate or non availability of irrigation. About 70 per cent irrigation is done through wells or tube-wells energised mainly by grid-power or diesel generators. Approximately 60,000 farmers are waiting for grid-based electricity connections for irrigation. Extension of electric-grid is not feasible in far-flung areas; almost 70 per cent area in the State is classified as desert. Moreover, ground water has deteriorated rapidly in the last two decades. Out of 249 blocks, nearly 200 are in the highly critical zone. Almost 90 per cent of groundwater withdrawal in the State is utilised through flood or furrow-irrigation methods with mere 35 to 45 per cent water-use-efficiency. Rajasthan is blessed with one of the best solar insolation on earth (6-7 kWh/m^2/day) combined with maximum sunny days in a year, about 325, which makes it one of the most attractive destinations for harnessing solar energy for various purposes, especially irrigation (Fig. 1). It was thus envisaged that an integrated solar water pump scheme formulated by combining various stand-alone government schemes would be indeed beneficial for the region as well as its farmers. Subsidies available under various programmes were clubbed and the State committed to grant the total subsidy upto 86 per cent of the capital cost. The departments of agriculture, finance and energy of the State, and Union government's ministries for Agriculture (MoA) and New and Renewable Energy (MNRE) worked in tandem along with various stakeholders to make it is seamless and successful project.

> **RAJASTHAN IS BLESSED WITH ONE OF THE BEST SOLAR INSOLATION ON EARTH (6-7 kWh/M^2/DAY) COMBINED WITH MAXIMUM SUNNY DAYS IN A YEAR - ABOUT 325 - WHICH MAKES IT ONE OF THE MOST ATTRACTIVE DESTINATIONS TO HARNESS SOLAR ENERGY.**

IMPLEMENTATION

The solar water pump scheme was scaled up from a mere target of 50 in 2010-11 to 500 (900 per cent increase) in 2011-12; to 2,200 (over 340 per cent increase) for 2012-13; and, to 10,000 (354 per cent increase) for 2013-14. Implementation at large scale was initiated in year 2011-12 when out of 33 districts, 14 districts were covered. Next year i.e. 2012-13 the scheme covered all the 33 districts in the State. Plans are being made to install a total of 100,000 solar water pumps in the next five years. Year-wise target, achievement, etc., are depicted in table 1.

PROJECT GOALS, SUSTAINABILITY AND EFFICIENCY

Project goals

- Enhancing irrigated area in the State
- Increasing productivity of the irrigated area
- Enabling farmers to diversify to remunerative high-value horticulture crops
- Conserving water by utilisation of efficient irrigation methods
- Narrowing the gap between grid-power demand and supply in the State

TABLE 1: Year-wise Target, Achievement, etc.

YEAR	PROJECT	NO. OF DISTRICT COVERED	TARGET	ACHIEVEMENT	PROJECT COST (Rs. Cr.)	MWp	PUMP CAPACITY (WP)	SUBSIDY	FUNDING SOURCE
2008-09	Government Farms	7	14	14	0.75	0.025	1800	100%	RKVY
2010-11	Pilot Project	6	50	34	1.83	0.097	2200/ 3000	86%	JNNSM, RKVY
2011-12	First major jump	14	500	1,675	95.86	4.967	2200/ 3000	86%	JNNSM, RKVY
2012-13	Second major jump	33	2,200	4,000	258.29	13.340	2200/ 3000	86%	JNNSM, RKVY State
2013-14 (Projected)	Third major jump	33	10,000	10,000	584.69	30.000	2200/ 3000	86%	JNNSM, RKVY, State

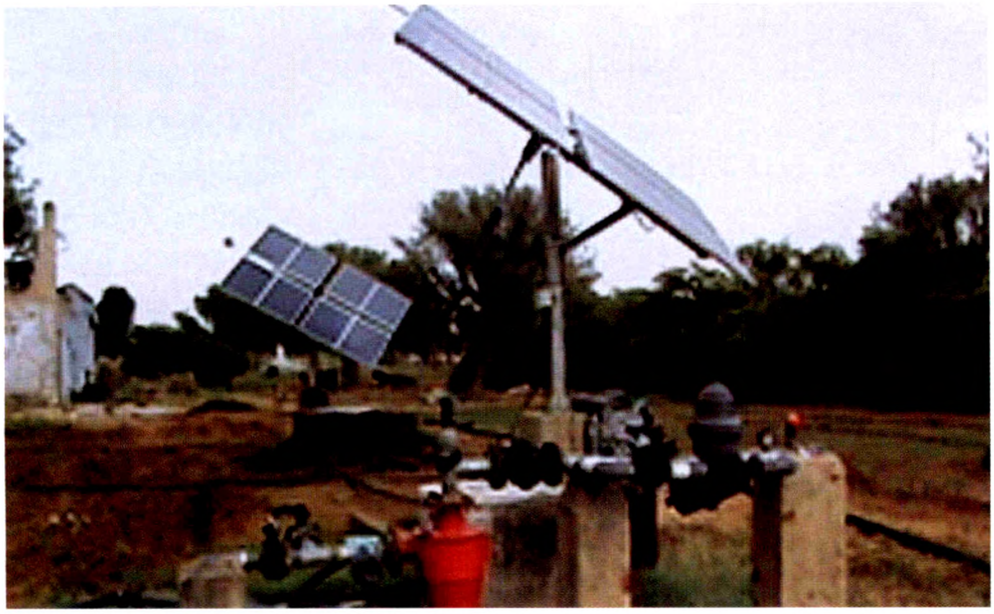


Fig. 1: Solar water pump system – with drip irrigation

- Reducing the queue of aspirant farmers for grid connection for irrigation
- Harnessing solar-energy resources available in abundance in the State
- Replacing the expensive and polluting diesel pump-sets
- Providing irrigation facility to farmers living in remote locations where grid is less likely to be extended in near future
- Saving farmers from the drudgery of night or erratic irrigation schedule
- Making environment sustainable and reducing the State's carbon footprint

By installing solar water pumps, many farmers who are 'off grid' are able to access electricity which allows them to enjoy modern amenities from watching television, using computers and studying at night to recharging cell phones. Also special vocational activities have been created with the advent of the solar power. Refrigeration has become a reality which expands the 'shelf life' of perishable food and is extremely important for life saving medicine. Plans for incorporation of solar powered water purification system for drinking is on the anvil in Rajasthan. The increased income generation provides a strong economic incentive for end-users to keep the systems in operation. Further, the farmers are being motivated through education and training to keep the pump in good working condition.

INNOVATIVE ASPECTS

Convergence of schemes and subsidies: A large number of Government of India (GoI) schemes are being implemented by the State's horticulture department, comprising of National Horticulture Mission (NHM), National Mission on Micro Irrigation (NMMI), National Mission on Medicinal Plants (NMMP), National Bamboo Mission (NBM), Jawaharlal Nehru National Solar Mission (JNNSM), Rashtriya Krishi Vikas Yojana (RKVY), and State Plan Programmes. All these schemes were studied in detail and various permutations and combinations were examined. Finally, the water harvesting structure (WHS) schemes for creation of surface water resources like farm ponds and drip irrigation under NHM were combined with JNNSM, RKVY, and the State resources. Functionally, the base was the JNNSM on which other schemes were made to ride. Financially, the resources were tied; 30 per cent subsidy under MNRE and 56 per cent subsidy from RKVY; if RKVY support dwindled, the State government was to fill the gap to make the total subsidy total 86 per cent. Presuming that the cost of a solar pump system is about Rs. 5,00,000, the farmer would need to pay only Rs. 70,000 (14 per cent of solar pump system cost) - equivalent to the cost of the pump. The figure of 86 per cent subsidy was thus arrived at.

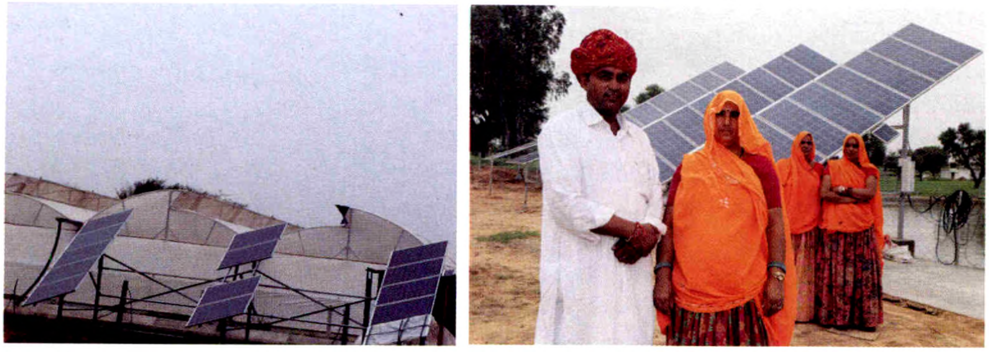
Political will: The solar pump programme targets were made part of the Chief Minister's Budget announcements so that the initiative gets acceptance, and focused efforts were made at all levels, particularly for arranging funds through MNRE, RKVY, or the State through its finance department. The RKVY is an additional and almost untied source of funding for state schemes. The horticulture department could prevail over RKVY source once the solar pump programme started showing significant progress; the initiative proved to be an efficient utiliser of RKVY funds, and subsequent funding from RKVY came more easily.

Decentralization: Earlier, sanctions, payments, etc. were released only from the State headquarters but, with large scale enhancements of targets, the system of issue of sanction, release of funds to firms, etc. was decentralised and the district authorities were empowered to issue the same. The District Horticulture Development Societies (DHDS) under chairmanship of District Collectors were made effective entities in implementing the scheme. Initial reservations at the State headquarter were removed with the gradual success of the programme and close interactions with field functionaries, collectors, and public representatives. The decentralisation freed the skeletal state level staff and allowed them to concentrate on policy and its implementation; the beneficiaries too did not need to come to State capital for work related to the scheme.

Solar panel manufacturers: Initially, there was a great debate whether manufacturers of solar panel alone, or motor alone, or suppliers of solar panels or motors be permitted to bid. After a lot of deliberations it was decided that only manufacturers of solar panels could bid. The overall average cost of the solar pump system of about Rs. 5,00,000, almost 80 per cent of which if for the solar panels, and remaining 20 per cent accounts for motor and allied equipment. It was decided that only solar panel manufacturers, who could actually maintain the system after supply, could bid.

THE SOLAR PUMP PROGRAMME TARGETS WERE MADE PART OF THE CHIEF MINISTER'S BUDGET ANNOUNCEMENTS SO THAT THE INITIATIVE GETS GENUINE ACCEPTANCE.

« Solar water pumps



Farm yields are found to be increasing with the use of solar water pumps

STRUCTURAL PROVISIONS FOR SUSTAINED SUPPORT

Maintenance: It is mandatory for the firms to guarantee free-of-cost maintenance for five years from the date of installation and then after-sales service for another five years. This condition was borrowed from earlier experience of the public works department, that the condition and quality of roads constructed by the contractors with a five year maintenance clause was more superior than the roads constructed with one year maintenance. Thus larger the maintenance period obligation the better the quality, as the contractor tries to save himself from future problems. The maintenance is ensured with the arrangement of technical and other staff.

Insurance: The equipment is insured against natural calamities etc.

Civil work: The solar pump system must be supported on six legs firmly entrenched through civil structures that can primarily bear wind load. The supplier should provide an additional light outlet of 100W for lighting during pump operation and one home lighting system, as an integral part of the system.

Testing: One major snag in the solar pump scheme was unreliable test reports about solar panel and pump performance. The facilities of MNRE viz. solar lab at Gurgaon, was visited by the authorities to see the testing procedures and reporting of results, under various conditions.

Management information system: A 43-column format has been developed, to be maintained by manufactures, and district and state authorities, which will be helpful in development of an integrated system.

TRANSPARENCY AND STAKEHOLDER PARTICIPATION

Transparent selection of beneficiaries: The applications from the prospective beneficiaries were obtained by district authorities in widely advertised campaigns so that every farmer had equal accessibility and opportunity to apply. When number of applications received was larger than the target for the district, then selection of beneficiaries was made by a draw of lottery, and the list of the selected beneficiaries was declared publicly.

Transparent e-tendering: In order to establish transparency, e-tendering was resorted to. Adequate time-line, pre-bid conferences and removal of confusions ultimately led to short-listing of 4 manufacturers for 2011-12 and 12 for 2012-13. Two stage bidding, technical and financial, was adopted. Once the vendor for L-1 was declared, most of the other bidders agreed to supply at L-1 price which became a benchmark for the whole State. The installations being widely dispersed, short-listing of a large number of manufacturers proved to be a boon.

Involvement of farmers in supplier selection: The selection of a supplier for the solar pump system, out of the empanelled firms was left to the beneficiary i.e. farmer.

A interaction between the beneficiary and prospective supplier indirectly imparted considerable technical knowledge and prompt after-sale service arrangements to the beneficiary. This liberty to beneficiaries brought in transparency in the whole process, and the suppliers competed to win the trust of the beneficiaries.

INTEGRATED SOLAR WATER PUMPS HAVE INCREASED THE AVAILABILITY OF WATER FOR IRRIGATION AND THE CULTIVABLE LAND AS COMPARED TO THE FLOOD IRRIGATION.

ECONOMIC AND SOCIAL IMPACTS

Impacts on livelihood: The initiative has made far-reaching desirable impacts to the lives of farmers and their families, conserved the resources precious to the State (groundwater and energy), and harnessed the clean and free solar energy. This stand-alone initiative has been contributing effectively towards addressing the multiple challenges of:

- enhancing the total irrigated area under cultivation in Rajasthan while reducing groundwater and grid-connected electricity consumption/requirements by utilising solar power available in abundance and deploying drip-based micro-irrigation systems at large scale.
- addressing some of the most crucial challenges being faced by Rajasthan viz. need for efficient utilisation of water resources; reducing the gap between power demand and supply; enhancing irrigated area thereby agriculture productivity; harnessing solar-energy resources available in abundance.
- making agriculture a remunerative occupation for farmers by way of replacing the requirement of expensive grid-power with solar power and by facilitating enhancement of farm productivity,
- saving precious groundwater by promoting drip-based efficient irrigation system that has 90 per cent water-use-efficiency compared to 30-45 per cent in case of flood or furrow method.

Successful deployment of integrated solar water pumps has increased the availability of water for irrigation and the cultivable land as compared to the flood irrigation. Access to water has increased agricultural production. Yield of crops, particularly horticulture crops, increased substantially (3-4 times) by incorporating additional agricultural technologies like greenhouse, polynet, shade-net and fertigation, and cultivating exotic produce like pomegranate, coloured capsicum, and gerbera flowers. Thousands of farmers, especially small holding farmers have significantly improved their quality of lives.

Service delivery time: Earlier the Department was catering to only about 50 solar pump systems in 2010-11, but it increased to about 4,500 units in 2012-13. As a corollary, the service time per unit has reduced correspondingly.

Evaluation: Rakesh Dalal, Indian Institutes of Technology (IIT), Mumbai, 'Assessment of Solar Pump Scheme in Rajasthan', June 2013, concluded "more than 50 per cent of the farmers were able to recover the invested amount within 1 to 2 years…100 per cent farmers are satisfied with the performance of the solar pump(s)" Nidhi Prabha Tewari in her research supported by IWMI-TATA in 2012 'Solar Irrigation Pumps - The Rajasthan Experience' concluded "…solar pumps are seen as a potential powerful solution to government's inability to provide agriculture power connections and farmers are seeing solar pumps as both a pumping and an energy solution". Institute of Public Auditors of India's independent evaluation states that the "... department has done a commendable job towards developing solar energy of approximately 50,000 kWp capacity by the end of 2013-14 in a very short span of almost three years (2011-14)".

REPLICATION POTENTIAL

Rajasthan has become a world leader in the area of integrated solar water pump systems. The technology, systems, and models have been well proven in Rajasthan, where more

There are more than 6,000 solar water pumps in all the 33 districts of Rajasthan

than 6,000 solar water pumps in all the 33 districts of the State have been successfully installed, a national record as certified by the 'Limca Book of Records'. The experience and learnings of installations in Rajasthan can be leveraged for significant scale up elsewhere on similar lines. Now that the technology; and administrative, financial, and regulatory systems have been tried and firmed up, replication everywhere will be limited mainly by the resources available.

Rajasthan was the lone State which had innovated, scaled up and implemented the programme successfully. Presentations of Rajasthan's experience were done in the states of Tamil Nadu and Maharashtra. Presentations are to be made in Assam, Himachal Pradesh, Karnataka and Uttar Pradesh. Planning Commission, GoI, too is to be given a presentation relevant to secretaries to GoI. The scheme was also presented in the Michigan State University, USA, which is supporting proposals under USAID for countries like Liberia, Kenya and Malawi.

A huge potential exists for bringing the costs down with economies-of-scale and thereby creating a self-sustaining market with minimal governmental support. The solar technology is foolproof and large scale replication of the scheme for the farmers of India is possible. The manufacturers may operate the project on build operate transfer (BoT) basis with the assistance of the government. Large scale adoption and production of solar energy will lead to further cost cutting. The feasible costing and the assistance from the state or central government will encourage more farmers to opt for the technology. With the partnership of state energy departments and corporations, and private partners, the technology can be disseminated at a large scale. Private entrepreneurs can invest in agriculture and rural sector through BoT. In India, there is vast scope of replication, with estimated 2,00,000 solar pumps (on surface or ground water bodies, depth up to 100 m, power up to 5 HP) in next 5 years. The expected total investment, at Rs. 5,00,000 a system, is Rs. 10,000 crore (1.6 billion USD).

It is estimated that the Rajasthan initiative, with 1,00,000 solar pumps installed in next 5 years, will extend the irrigation facility to additional 3,00,000 hectare resulting into a productivity enhancement.

ENVIRONMENTAL IMPACT - EMISSIONS/CLIMATE PROTECTION

The improvements owing to solar initiative are estimated in table 2. With 4,000 solar pumps, most of them of 3000Wp each, the installed capacity is about 12 MWp during 2012-13. This has resulted in replacing the generation of grid-electricity, generated mainly through consuming conventional fuels like coal and gas. Many of the solar

TABLE 2: Measurable Indicators - Rajasthan Solar Pump Programme 2012-13

ITEM	UNIT	TOTAL
No. of pumps in 2012-13	no.	4,000
Average solar pump capacity	Wp	3,000
Equivalent electric power saved (4000x3000 Wp)	MWp	12
Duration in hours a pump runs/day	hrs.	6
No. of units (kWh) saved per day	kWh	18
No. of days a pump runs in a year	days	200
No. of electric units saved per pump per year 18x200	kWh	3,600
Cost per kWh of electricity	Rs.	5
Money saved by solar pump per year 3,600x5	Rs.	18,000
Conventional grid, distribution capital cost saved (not considered)	Rs.	-
Diesel cost saved per year (diesel generation twice costly than electric)	Rs.	36,000
Diesel saved per pump per day	litre	3
Diesel saved per pump per year	litre	600
Diesel saved total, per year (4000x600)	million litre	2.4
Foreign exchange saved per year, crude price @ Rs. 20/litre	Rs. million	48
Diesel subsidy saved by Govt. per year (24,00,000 x Rs. 10/litre)	Rs. million	24
Diesel subsidy saved by Govt. in 15 years (Rs. 2.4 Cr x 15 years)	Rs. million	360
Area Irrigated per pump per crop	Ha	3
Area irrigated total, 2 crops a year (4000 pumps x 2x 3)	Ha	24,000
Water required for surface irrigation per Ha	cubic meter	5,000
Water saved per Ha due to drip irrigation (40 per cent of 500)	cubic meter	2,000
Total water saved, 24,000x2,000	MCM	48
Additional production value due to irrigation through solar pumps	Rs.	1,00,000
Total additional production value due to irrigation through solar pumps	Rs. million	2,400
CO_2 Emission for one 1 kWh electricity produced by diesel	kg	0.29
Total CO_2 generation avoided, 12,000 kWh x 0.29 kg	kg	3,480
Curtailment in farmers' wait-list for electric connection	Nos.	4,000

water-pumps have been installed in the areas where grid-electricity is unavailable or inadequate.

An estimated 12,000 ha of additional land has been brought under irrigation. With at least two crops every year compared with the earlier scenario of having just one monsoon-fed crop in entire year, 24,000 ha has been irrigated. Many farmers have growing three crops a year and have opted to far more remunerative horticulture/cash crops including vegetables and fruits.

Migration to mandatory drip irrigation (it has at least twice the water use efficiency viz-a-viz furrow method) has saved 48 million cubic meter water. Also 2.4 million litre diesel; Rs. 24 million diesel subsidy; Rs. 48 million foreign exchange is saved annually. Estimated emission of 3,480 kg of CO_2 has been avoided.

> **THE SCHEME, WITH 1,00,000 SOLAR PUMPS INSTALLED IN NEXT 5 YEARS, WILL SIGNIFICANTLY CURTAIL THE LONG QUEUES OF FARMERS WAITING FOR ELECTRIC CONNECTION.**

ISSUES AND CHALLENGES

The Rajasthan initiative has identified a number of important challenges and opportunities, for the central and state governments, manufactures, scientists, and so on, which can drastically change the scenario for the use of solar energy in rural areas. The major challenges are storage of unused solar energy, increasing usage of solar energy in domestic and community lighting, agriculture, and small scale industry; connecting with the conventional grid; low cost funding through UN agencies, federal/state governments, CSR; linkages with MNREG etc; mass manufacturing and cost reduction.

The possible opportunities are integration of schemes in the country; national MIS; maintenance, insurance, control room, BPO service; R&D for solar in agriculture/horticulture; solar parks dedicated to use of solar energy in horticulture/agriculture; sharing of experiences with countries such as the Netherlands and Israel for efficient use of water and solar energy.

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सत्यमेव जयते

'AKSHAY URJA' WELCOMES

DR. SATISH BALRAM AGNIHOTRI,

Secretary, MNRE

Dr. Agnihotri has recently joined the Ministry of New & Renewable Energy (MNRE) as Secretary to the Government of India. He was previously the Director General (Acquisition) in the Ministry of Defence. He coordinated and managed the entire capital acquisition programmes for the Indian Army, Navy, Air Force and the Coast Guard. This assignment involved addressing a wide range of policy, commercial and operational issues relating to capital acquisition, including a host of bilateral defence cooperation issues. Dr. Agnihotri, prior to that had a short stint as Additional Secretary in the Ministry of Agriculture discharging the role of Financial Advisor from June to October 2012. He was the Director General of Shipping during 2010-12. He has worked as Joint Secretary in the Cabinet Secretariat, Transport Commissioner, Odisha and Secretary, Women and Child Development and General Administration Department. He was Vice Chairman, Cuttack Urban Development Authority, Odisha. CEO of the Odisha Renewable Energy Development Agency, Director, Industries and District Magistrate in Dhenkanal District. He also worked with UNICEF, Kolkata as consultant on Child Nutrition and Health.

An IAS officer of Odisha cadre of the 1980 batch Dr Agnihotri has done his Master's degree in Physics followed by M.Tech in Environment Science and Engineering from IIT, Bombay. He later did an MA in Rural Development followed by a Ph.D on Sex Ratio Patterns in Indian Population from School of Development Studies, University of East Anglia, Norwich, UK. His research on declining sex ratios in India has been cited by scholars including Prof. Amartya Sen. He also writes satire and science fiction in Hindi. He is Visiting Professor at IIT, Mumbai in its Center for Technology Alternatives for Rural Areas. He belongs to Dharangaon in the Jalgaon District of Maharashtra.

'Akshay Urja' welcomes Dr. Agnihotri, Secretary, MNRE.

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SOLAR BOTTLE BULB FOR THE DAYLIGHT DEPRIVED

The solar bottle bulb was invented by Alfredo Moser, a Brazilian mechanic, in 2002. In this experiment, the solar bottle bulb and a regular bulb were compared at different times of day to analyse their brightness using a luxmeter.

ADARSH MOHAN DIXIT

Solar products include a variety of technology related options but in Manila, Philippines, electricity and solar was both put to use in making a solar bottle bulb. Taking cue from this project we set out to compare and analyse the brightness of a regular light bulb and a solar bottle bulb using a luxmeter, at different times of the day. We hypothesized that the brightness of the solar bottle bulb when compared to the average brightness of a regular bulb, would be brighter during the day. The materials used were a water/soda bottle, 1 inch x 1 inch roof sheet material, purified water, chlorine/bleach, rubber sealant, and a lux meter.

TABLE 1: Comparing Bottle Bulb to Regular Bulb

DAY	TIME	BOTLE BULB (LUX)	SUN (LUX)	ELECTRIC BULB (LUX)
First	3:30 pm	328.6	285.9	528.3
Second	3:10 p.m.	424.3	164.3	274.6
	4:00 p.m	455.5	389.0	413.9
Third	3:10 p.m.	345.3	297.4	276.6
	4:00 p.m	280.8	309.9	214.2
Fourth	3:10 p.m.	287.0	389.0	249.6
	4:00 p.m	285.0	289.1	201.8
Fifth	3:10 p.m.	162.2	260.0	413.9
	4:00 p.m	235.0	145.6	484.6

Once the bottle bulb is in place, made in accordance to well publicized material over the internet, the bulb was tested at different times of the day for the efficacy of its brightness. It is understood that this simple innovation is not perfect. The water needs to be replaced regularly and without any provision for energy storage, the bulb does not work at night. However, the bottle bulb was found to be brighter during daylight compared to the regular bulb. Therein lies the advantage for communities that are daylight deprived. The power of the sun allows the poor in congested settlements to use the solar bottle lamp to make their homes more lighted. The bulb does not have or produce any pollutants and also reduces fire hazard. ❂

THE AIM OF OUR PROJECT WAS TO ANALYZE THE BRIGHTNESS OF A REGULAR LIGHT BULB AND A SOLAR BOTTLE BULB USING A LUXMETER, AT DIFFERENT TIMES OF DAY.

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100 kWp SPV POWER PLANT AT NIT TRICHY

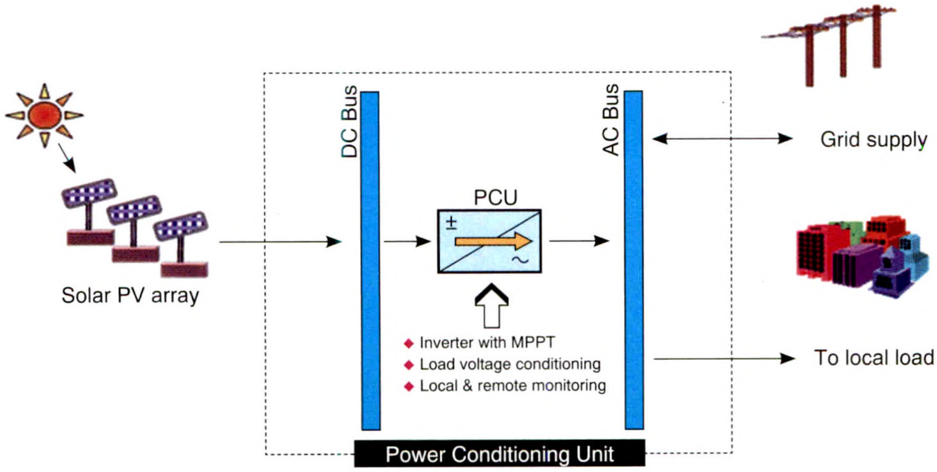
When power cuts started affecting academics, NIT Trichy decided to go the solar way. With no dearth of roof tops on the sprawling campus, a proposal was initiated for a 100 kWp roof top, grid interactive SPV power plant.

A K BAKHTHAVATSALAM

Solar Panel at NIT Trichy.

NIT (formerly REC) Trichy is a premier T-School in the country which is ranked consistently amongst the top 10 institutes in India. The sprawling 800 acre campus is in a geographical location which is blessed with abundant solar power with an average insolation of about 5.8 kWh/m^2/day. Trichy is hot and dry for at least eight months of the year.

At a time when the Institute was marching towards its golden jubilee year, the state of Tamil Nadu was going through an acute shortage of power. With 10-12 hours of power cut in a day, this was adversely affecting academics. Diesel generators were pressed into



« Diagrammatic representation of rooftaop SPV power plant

service to overcome the power outages imposed by the electricity board. This in turn led to concerns of rising energy costs and adverse impacts on the environment in terms of both air and noise pollution. It was then that the Institute decided to go the solar way and avail benefits under the Jawaharlal Nehru National Solar Mission (JNNSM) scheme. With no dearth of roof tops on the sprawling campus, a proposal was initiated for a 100 kWp roof top grid interactive SPV power plant. The lecture hall complex was chosen for the project. As the proposal was shaping up, the Tamil Nadu Government unveiled its Solar Energy Policy, 2012 which covered a specific policy on solar purchase obligation (SPO). The SPO mandates 6 per cent of consumption by January 2014 for all high tension consumers including educational institutions.

The complete engineering, procurement and construction services (EPC) was done by BHEL Electronic Division (BHEL EDN), Bangalore. The entire design, erection, installation, commissioning and operation were completed within a short time and the power plant was commissioned on June 21, 2013. Mono crystalline solar panels (240 Vp) have been used in this power plant manufactured by BHEL EDN. The complete online data is being stored in a data logger and remote monitoring of the data has also been enabled. The power plant has generated around 48,000 units in about four months with an average generation of about 400 units per day. Apart from savings in energy charges, the plant has also helped in shaving peak consumption, as the actual consumption was exceeding the contractual demand of 1250 kVA on some occasions. The plant is estimated to generate around 1.4 lakh units every year and also to help reduce CO_2 emissions by about 112 tonnes annually. The only maintenance work which is done regularly is panel cleaning as the air in Trichy region is often dust laden.

A simple economic comparison of the SPV with a diesel generator shows that about 45000 litres of diesel is required to produce 1.4 lakh units (at 3 kWhr per litre). With the price of diesel increasing by the day, the payback of the SPV power plant vis-a-vis a DG set works out to around two and half years only. Encouraged by the success of this project, NIT Trichy is actively considering increasing its solar generation substantially. Besides the financial and environmental benefits, the plant has become a live demonstration of renewable energy and an inspiration for students to embrace solar energy as a way of life.

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PLASMONIC SOLAR CELLS

Plasmonic solar cells (SCs) have great potential to drive down the cost of solar power. To make SC a viable energy source, trapping of light is crucial for thin film SCs. So, plasmonic nanoparticles could be used to increase the efficiency of thin film SCs.

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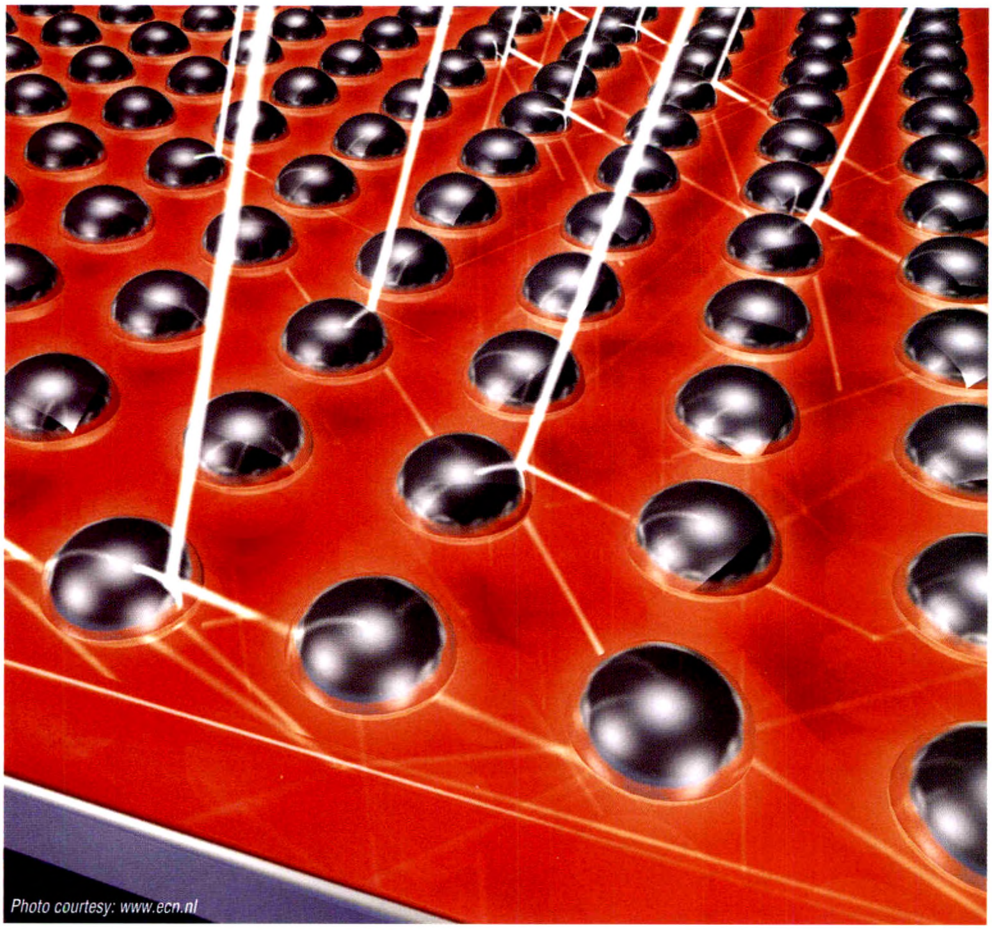
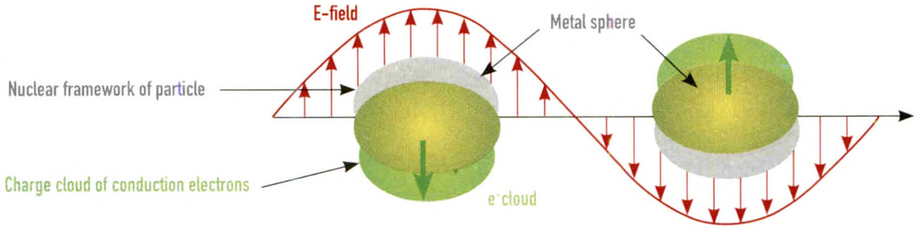


Photo courtesy: www.ecn.nl

« Plasmonic Solar Cells

A solar cell (SC) is a device that converts sun light energy directly into electricity by the photovoltaic effect. Photovoltaics have the potential to make a large contribution for solving the problem of climate change and hence, require highly efficient solar cells. SCs can be divided into three different generations. The first generation SCs are made from crystalline semiconductor wafers, typically silicon with a thicknesses of 200-300μm. Currently 90 per cent of the solar cell market is based on first generation SCs and around 40 per cent of the cost of a solar module is due to thick silicon wafers. Second generation SCs based on thin film technology have thickness usually in the range 1-2μm, deposited on cheap substrates such as glass, plastic or stainless steel. These SCs focus on lowering the amount of material used as well as increasing the energy production. They are made from a variety of semiconductors including cadmium telluride and copper indium diselenide, as well as amorphous and


E-field
Metal sphere
Nuclear framework of particle
Charge cloud of conduction electrons
e⁻cloud

The generation of surface plasmons on nanosphere

THE THIRD GENERATION SOLAR CELLS WILL BE ABLE TO IMPROVE ABSORPTION AND HENCE EFFICIENCY BY INCREASING THE LIGHT TRAPPING OF DESIRED FREQUENCY.

polycrystalline silicon. A major limitation in thin film SCs technology is their ineffective absorbance near bandgap, in particular for the indirect bandgap semiconductor silicon. Therefore, it is very important to trap light inside the SC in order to increase the absorbance. Third generation SCs are currently being researched with the goal to increase the efficiency using second generation SCs. They are envisaging to improve absorption and hence efficiency by increasing the light trapping of desired frequency. A part of third generation SCs that has emerged recently is the use of scattering from noble metal nanoparticles excited at their localized surface plasmon resonance (LSPR) which is discussed here in detail.

BASIC PRINCIPLES

When a photon hits a semi-conductor, one of three things can happen: (i) The photon (lower than Si band gap energy) can pass through the material; (ii) The photon can reflect off the surface and (iii) The photon (higher than Si band gap energy) can be absorbed by the silicon.

When a photon is absorbed, its energy is given to an electron in the crystal lattice. Usually, this electron is in the valence band and is tightly bound in covalent bonds with neighbouring atoms and hence, unable to move far. The energy given to it by the photon "excites" it into the conduction band, where it is free to move within the semiconductor and hence, deficiency of one electron called "hole" is created. The presence of a missing covalent bond allows the bonded electrons of neighbouring atoms to move into the "hole" leaving another hole behind, and in this way a hole can move through the lattice. Thus, it can be said that photons absorbed in the semiconductor create mobile electron-hole pairs. Once the electrons and holes are separated, they need to recombine, since they are of opposite charge. The SCs are pretty efficient if the electrons can be collected before this happens. The way to collect the electrons quickly would be to make the conducting material very thin. If the surface is made very thin, there will be less light absorbed by the device. Much of the solar radiation reaching the earth surface is composed of photons with energies greater than the silicon band gap. These higher energy photons will be absorbed by the solar cell, but the difference in energy between these photons and the silicon band gap is converted into heat via lattice vibrations called phonons rather than into useful electrical energy which can damage the cell. Different types of the SCs are:

- Crystalline silicon solar cells
- Thin-film solar cells
- Plasmonic solar cells

SURFACE PLASMONS

A noble metal nanoparticles exhibit a strong optical extinction (absorption + scattering) cross-section due to the collective oscillation of free electrons called LSPR. The resonance wavelengths are reported to be sensitive to the size, shape and surrounding medium of the nanoparticle. For the light to be trapped the absorption is not important, but the scattering of the light by metal nanoparticles is important, to utilize the light energy for highly efficient SCs.

Plasmonics: Scattering and Absorption by Metal Nanoparticles

The basic principle for the functioning of plasmonic SCs includes scattering and absorption of light due to the deposition of metal nanoparticles. A thin silicon sheet does not absorb light very well. For this reason, more light needs to be scattered across the surface in order to increase the absorption of Si to convert it into the useful electrical energy. It has been found that metal nanoparticles help to scatter the incoming light across the surface of the Si substrate at resonance wavelengths. The equations that govern the scattering and absorption of light for particles, which have dimensions less than the wavelength of light can be written as:

$$\sigma_{sca} = \frac{k^4}{6\pi}|\alpha|^2 \qquad \& \qquad \sigma_{abs} = k\,\mathrm{Im}(\alpha) \qquad (1)$$

The polarizability α of the particle is given by:

$$\alpha_x = \frac{4\pi}{3}ab^2\frac{\varepsilon_p(\omega)-\varepsilon_m}{\varepsilon_m + L_x(\varepsilon_p(\omega)-\varepsilon_m)} \qquad (2)$$

ε_p is the dielectric function of the metal particle, ε_m is the dielectric function of the embedding medium and L_x is the depolarization factor, which is the function of the particle shape. For spherical particles, when the polarizability of the particle becomes maximum resonance occurs. The dielectric function for metal with low absorption can be defined as:

$$\varepsilon_p = 1 - \frac{\omega_p}{\omega^2 + \iota\gamma\omega} \qquad (3)$$

ω_p is the bulk plasmon frequency and defined as:

$$\omega_p^2 = {Ne^2}/{m\varepsilon_0} \qquad (4)$$

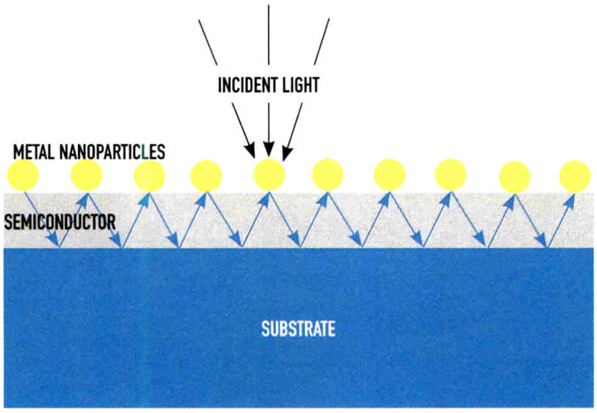
N is the free electrons density, e is the electronic charge and m is the effective mass of an electron. ε_0 is the dielectric constant of free space. Many of the plasmonic solar cells use nanospheres to enhance the scattering of light in such a case LSPR frequency in free space can be given as:

$$\omega_{sp} = \sqrt{3}\omega_p \qquad (5)$$

LSPR frequency for spherical particles primarily depends on the free electron density in the particle. The order of densities of electrons for different metals shows the type of light, which corresponds to the resonance.

✦ **Aluminum** - Ultra-violet ✦ **Silver** - Ultra-violet ✦ **Gold** - Visible ✦ **Copper** - Visible

If the dielectric constant for the embedding medium is varied, the resonant frequency can be shifted. Higher indexes of refraction will lead to a longer wavelength and broaden the resonance range. Gold is highly stable and shows the resonance peak broader than silver. Though silver is cheap in comparison to gold, it is highly unstable and gets oxidized, which affects the resonance frequency. On the other hand, copper is cheaper than silver,



PSC using metal nanoparticles

ONE OF THE MAIN FOCUSES HAS BEEN ON IMPROVING THE THIN FILM SCs THROUGH THE USE OF METAL NANOPARTICLES DISTRIBUTED ON THE SURFACE.

and more absorbent than gold. Aluminium shows the resonance frequency in the UV range and also shows oxidization effect. Plasmonic SCs are considered the future of the industry in comparison with any type of solar cells due to their high efficiency at the approximate cost of second generation of solar cells.

PLASMONIC SOLAR CELLS

Plasmonic Solar Cells (PSCs) have great potential to drive down the cost of solar power. To make SC a viable energy source, trapping of light is crucial for thin film SCs. So, plasmonic nanoparticles would be used to increase the efficiency of thin film SCs. The scattered light from plasmonic nanoparticles excited at LSPR make them efficient. The design of a PSC varies depending on the method being used to trap light through the material. A common design is to deposit metal nanoparticles on the top surface of the thin film SC. When light hits these metal nanoparticles at their surface plasmon resonance, it is scattered in many different directions. This allows light to travel along the SC and bounce between the substrate and the nanoparticles enabling the SC to absorb more light.

RECENT ADVANCES IN PSCs

There has been some pioneering work in the field of PSCs. One of the main focuses has been on improving the thin film SCs through the use of metal nanoparticles distributed on the surface. The increased scattering provides more photon availability, which causes electron excitation and hence, generates current.

Catchpole and Polman: In thin film SCs, path length enhancements up to a factor of 30 were found for optimized shapes as particle shape is a crucial parameter determining the light trapping efficiency.

Westphalen: Enhancement for silver clusters incorporated into indium tin oxide and zinc phthalocyanine solar cells.

Derkacs: Gold nanoparticles on thin-film silicon gaining 8.3 per cent of conversion efficiency.

Stenzel: Enhancements in photocurrent by a factor of 2.7 for indium tin oxide-copper phthalocyanine structures.

Stuart and Hall: Achieved enhancement in the photocurrent by a factor of 18 for a 165 nm thick silicon on insulator photo-detector at a wavelength of 800nm using silver nanoparticles on the surface of device.

Schaadt: Enhancements up to 80 per cent at wavelengths around 500nm was obtained by deposited gold nanoparticles on highly doped wafer-based solar cells.

Pillai: Photocurrent increase of 33 per cent and 19 per cent was obtained on 1.25μm thick silicon on insulator solar cells and planar wafer based cells via deposited silver particles.

Singh and Verma: Theoretical calculations show that Cu nanoparticles can be more useful than Al, Au and Ag nanoparticles to make plasmonic thin film Si solar cells.

APPLICATIONS OF PSCs

The applications for PSCs are endless. The need for cheaper and more efficient SCs is very high. In order to be considered cost effective, SCs need to provide energy for a smaller price than that of traditional power sources such as coal, gasoline or nuclear. The movement toward a greener world has helped to spark research in the area of PSCs. With new technologies (third generation), efficiencies of up to 40-60 per cent can be expected in comparison to first generation SCs whose efficiencies are 30-40 per cent. With a reduction of materials through the use of thin film technology (second generation), prices can be driven down. Certain applications for PSCs are given below:

Space Exploration Vehicles: the main contribution for this would be the reduced weight of the SCs. An external fuel source would also not be needed if enough power could be generated from the PCs. This would drastically help to reduce the weight also.

Rural Electrification: An estimated two million villages near the equator, with approximately 80 per cent of the world population, have limited access to electricity. When the cost of extending power grids, running rural electricity and using diesel generators is compared with the cost of solar cells, many times the solar cells win hands down. If the efficiency and cost of the current solar cell technology is decreased even further then many rural communities and villages around the world could obtain electricity. Specific applications for rural communities would be water pumping systems, residential electric supply and street lights.

Power Stations: If SCs could be produced on a large scale and be cost effective, then entire power stations could be built in order to provide power to the electrical grids. With a reduction in size, they could be implemented on both commercial and residential buildings with a much smaller footprint. The SCs could help to power high consumption devices such as automobiles in order to reduce the amount of fossil fuels used and to help improve environmental conditions.

Low Power Electronics: Essentially, SCs could be used to replace batteries for low power electronics. This would save everyone a lot of money and it would also help to reduce the amount of waste going into landfills. SCs could also provide power to lighthouses, or even battleships out in the ocean. It can also be applied to other electronic devices to make them self-power driven when the sun is out. There are solar cell phone chargers, solar bikes, solar cars that people can adopt for daily use.

CONCLUSION

Research in PSCs is rapidly exploiting the benefits offered by plasmonics in tandem with those of thin film technology. The advantages of using plasmonic particles is to use them on any thin film SC (silicon or organic). The metal nanoparticles of different size, shape and embedding medium can enhance the efficiency of the solar cells over a large range of the electromagnetic spectrum. Hence, PSCs are promising candidates to drive down the cost of solar energy generation with high efficiency. ✪

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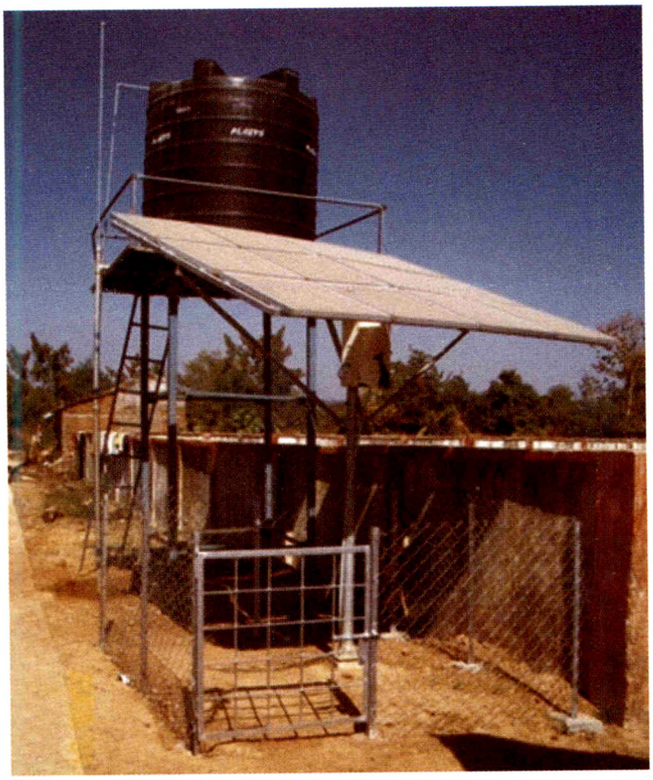
SOLAR PV PUMPING SYSTEMS

Solar photovoltaic water pumping systems are useful for irrigation and drinking water in rural areas, particularly during summer, when power failures are frequent.

PRABIR KUMAR NAIK



« Solar energy based drinking water supply scheme in rural Nagpur, Maharashtra.

Solar energy based dual pump/drinking water scheme is the most suitable option for rural India. In such a scheme a solar PV based submersible pump is installed in the bore well as well as a hand pump is fitted for supplying clean water on days when little or no solar power is available - for example on rainy days. The water supply scheme should have a bore well of yield not less than 2800 litres per hour (0.77 litre per second). Solar PV submersible water pump of 900 W with required PV panels and a 5000 litres HDPE (high density polyethylene) tank mounted on a 3m high pre fabricated steel structure need to be put in place. What a vast country like India needs is a de-centralised solar energy system such as solar water heaters, cookers, driers, lighting systems, disinfection systems for safe drinking water and solar and wind battery chargers. Generation of solar energy based electricity can reduce the demand for thermal power. As burning of fossil fuel has the major impact on climate change, such schemes can reduce the impact of climate change. ❂

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INTERESTING FACTS: BIOFUEL

- Henry Ford originally designed the Model T to run on ethanol, a biofuel.
- During World War II, the demand for biofuel increased as fossil fuels became less abundant.
- Biofuels are often broken into three generations - 1st generation biofuels (conventional biofuels), 2nd generation biofuels (produced from sustainable feedstock) and 3rd generation biofuel (derived from algae).
- Most biofuels are as energy dense as coal, but produce less carbon dioxide when burned.

Source: biofuel.org.uk

BIOGAS GENERATION, PURIFICATION AND BOTTLING: DEVELOPMENT IN INDIA

Biogas bottling plants are one of the most potent tools for mitigating climate change by preventing black carbon emission from biomass chulhas, since biogas is used as a cooking fuel. Also, methane emissions from untreated cattle dung and biomass waste are also avoided. The purified biogas is bottled in CNG cylinders and wherever CNG is currently used, bottled biogas can be used as an alternative.

M.L. BAMBORIYA

Biogas bottling project at Singla Bio-Energy, Siaghawali, Sri Ganganagar, Rajasthan.

Biomass resources such as cattle dung, agricultural waste and other organic wastes have been one of the main energy sources for mankind since the dawn of civilization. There is a vast scope to convert these energy sources into biogas which is a clean, low carbon technology for efficient management and conversion of fermentable organic wastes into a cheap and versatile fuel and bio/organic manure. It has the potential for leveraging sustainable livelihood development as well as tackling local and global land, air and water pollution. Biogas obtained by anaerobic digestion of cattle dung and other loose and leafy organic matter/biomass waste can be used as an energy source for applications like cooking, heating, space cooling/refrigeration, electricity generation and as gaseous fuel for vehicular application. Based on the availability of cattle dung from about 304 million cattle, there exists an estimated potential of about 18,240 million cubic meter of biogas generation annually.

India is implementing one of the world's largest programmes in renewable energy. The country ranks second in biogas utilization. Biogas can be generated and supplied round the clock in contrast to solar and wind, which are intermittent in nature. Biogas plants provide three-in-one solution of gaseous fuel generation, organic manure production and wet biomass waste disposal/management.

Biogas is a product of bio-methanation when fermentable organic materials such as cattle dung, kitchen waste, poultry droppings, night soil waste, agricultural waste etc. are subjected to anaerobic digestion in the presence of methanogenic bacteria. This process is better as the digested slurry from biogas plants is available for use as bio/organic manure in agriculture, horticulture and pisciculture as a substitute or supplement to chemical fertilizers. In contrast, when biomass is subjected to combustion or gasification process, it ends up in the destruction of biomass and only ash is left after extraction of energy. Therefore, the bio-methanation process of converting biomass into gaseous fuel is superior and sustainable process that to be preferred for such biomass material that can be processed in biogas plants.

India has been a pioneering country in developing simple and easy to operate biogas plants. The Khadi Village Industries Commission (KVIC) model, developed and promoted in India, has withstood the test of time and is also being promoted in a large number of Asian, Pacific and African countries. Latest in the efforts for technology improvement is the development and launch of fixed dome and portable, prefabricated high density polyethylene (HDPE) based 'complete and portable family size biogas plants' suitable for rural, semi-urban and urban areas. These portable biogas plants help to achieve the twin objectives of energy generation and better sanitation with the bonus of enriched bio/organic manure while meeting emergency lighting needs using biogas gensets and lamps. Initially, biogas plants were developed for digesting cattle dung. However, over a period of time technology has been developed for bio-methanation of various types of biomass materials and mixed feed. Biogas plant designs are now available from 0.5 m^3 to higher unit sizes and multiples of that can be installed for achieving higher biogas plant sizes depending on availability of the raw material for family, community, institutional, industrial and transport applications.

BIOGAS PLANTS PROVIDE THREE-IN-ONE SOLUTION OF GASEOUS FUEL GENERATION, ORGANIC MANURE PRODUCTION AND WET BIOMASS WASTE DISPOSAL/MANAGEMENT.

BIOGAS TECHNOLOGY DEVELOPMENT

Biogas eliminates drudgery of women and girl children from diseases caused by indoor air pollution arising due to direct burning of cattle dung and biomass in rural hearths. The history of biogas technology development in India is given as below:

1897: Biogas from human waste to meet lighting needs at the Matunga Leper Asylum, Bombay.

1939: Principle of biogas production from cattle dung was first evolved at the Indian Agricultural Research Institute, New Delhi.

1951: Field-worthy model of floating drum type biogas plant developed

1961: Khadi and Village Industries Commission (KVIC) took up floating drum type biogas plant for extension.

1979: Fixed dome Janta model biogas plant developed by the biogas research station, Ajitmal, Etawa, U.P.

Late 1980s: UASB (Upflow Anaerobic Sludge Blanket) technology developed for medium and large size biogas plants for processing urban and industrial biomass wastes.

1981-82: National Project for Biogas Development (NPBD) to cater to family size biogas plants launched.

1986: Deenbandhu model fixed dome biogas plant developed by Action for Food Production (AFPRO), New Delhi.

1988: BIS standard adopted for biogas stoves.
1989-90: BIS standards adopted for KVIC type Pragati and Deenbandhu with brick-masonry models of biogas plants.
2002-03: NPBD modified and renamed as National Biogas and Manure Management Programme (NBMMP).
2006: Biogas based decentralized power/energy generation programme launched.
2008-09: New initiative taken for technology demonstration on biogas bottling (BGFP) under RDD&D.
2011: MNRE supported first biogas bottling project commissioned.
2013: Indian Standard on Biogas (Biomethane) IS:16087 adopted.
2013: Scheme launched on biogas bottling under programme on energy from urban, institutional and agricultural waste/ residues.

BIOGAS COMPOSITION AND PROPERTIES

Biogas comprises of 60-65 per cent methane, 35-40 per cent carbon dioxide, 0.5-1.0 per cent hydrogen sulphide, rest being water vapour etc. Biogas is a non-toxic, colourless and flammable gas. It has an ignition temperature of 650 - 750°C. Its density is 1.214kg/ m^3 (assuming about 60 per cent methane and 40 per cent CO_2). Its calorific value is 20 MJ/m^3 (or 4700 kcal). It is almost 20 per cent lighter than air. Biogas, like liquefied petroleum gas (LPG), cannot be converted into the liquid state under normal temperature and pressure. It liquefies at a pressure of about 47.4 kg/cm^2 at a critical temperature of -82.1°C. Removing carbon dioxide, hydrogen sulfide, moisture and compressing it into cylinders makes it easily usable for transport applications as well as for stationary applications. Already CNG technology has become easily available and therefore, bio-methane (purified biogas) which is nearly same as CNG, can be used for all applications for which CNG is used. Purified biogas (bio-methane) has a higher calorific value in comparison to raw biogas.

BIOGAS PROGRAMMES

The main schemes being implemented by the MNRE under biogas programmes are given below:

National Biogas and Manure Management Programme (NBMMP): The NBMMP, which mainly caters to setting up of family type biogas plants, has been implemented since 1981-82. NBMMP provides for central subsidy in fixed amounts; turnkey job fee linked with five year's free maintenance warranty; financial support for old, non-functional plants for repair; training of users, masons, entrepreneurs etc.; publicity and extension; administrative charges or staff support and Biogas Development and Training Centres (BDTC). In order to provide training support and technical back-up, 13 BDTCs have been set up in universities, Indian Institute of Technology (IITs) and other technical institutes.

Under this programme about 4.67 million biogas plants have been installed against the potential of 12 million biogas plants in the country for cooking, lighting and pumping application; it has 39 per cent of the potential estimated for installation of biogas plants in the country. Various models were developed indigenously and installed such as pre-fabricated model biogas plant, floating dome type biogas plant, bag type biogas plant and fixed dome biogas plant.

Biogas Based Distributed/Grid Power Generation Programme (BPGP): BPGP was launched in January, 2006 for installation of biogas based power projects in the capacity range of 3 kW to 250 kW to provide electricity to individual or community or grid. So far, such projects having total capacity of about 3.5 MW have been installed in the country.

Programme on energy from urban, industrial and agricultural wastes/residues (including production of bio–CNG for filling into gas cylinder): The Ministry is promoting energy recovery from a variety of waste, such as municipal solid waste, sewage treatment plant, cattle dung, agricultural waste or residue, urban and industrial waste. So far, such projects having total capacity of about 212 MW have been installed in the country.

R&D programme on biogas: The Ministry also supports research, design, development & demonstration (RDD&D) to develop new and renewable technologies, processes, materials, components, sub-systems, products and services, standards and resource assessment so as to indigenously manufacture renewable energy products and develop systems. Thirteen R&D projects on biogas have been supported by the Ministry.

Technology demonstration on biogas bottling under RDD&D: In 2008-09, a new initiative was taken for technology demonstration on biogas bottling projects in entrepreneurial mode, for installation of medium size mixed feed biogas plants for generation, purification and bottling of biogas under RDD&D policy of MNRE. Installation of such plants aims at production of CNG quality of compressed biogas (CBG) to be used as vehicular fuel in addition to meeting stationary and motive power, electricity generation, thermal application etc. needs in a decentralized manner through establishment of a sustainable business model in this sector. There is huge potential for installation of such plants in various areas. Under the demonstration phase, the Ministry has sanctioned central financial assistance for a limited number of such projects for implementation following an entrepreneurial mode in Chhattisgarh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Madhya Pradesh, Andhra Pradesh and Rajasthan.

SO FAR, EIGHT BIOGAS BOTTLING PROJECTS OF VARIOUS CAPACITIES AND TECHNOLOGIES HAVE BEEN COMMISSIONED IN THE COUNTRY FOR FILLING AND STORAGE OF COMPRESSED BIOGAS IN CNG CYLINDERS.

So far, eight biogas bottling projects of various capacities and technologies have been commissioned in the country for filling and storage of compressed biogas in CNG cylinders, after obtaining required licenses from Petroleum and Explosives Safety Organization (PESO), State Pollution Control Board (PCB) etc. The biogas obtained has more than 90 per cent methane; this has been corroborated through tests conducted by National Accreditation Board for Testing and Calibration Laboratories (NABL). The biogas is compressed to 150 bar pressure for filling in cylinders. The purified biogas is equivalent to CNG.

The purified biogas is filled in a CNG cylinder and supplied to mid-day meal scheme, community kitchen, mess, hotels, industries etc. for various purposes such as cooking and heating. The slurry which comes out of the biogas plant is directly or after drying used as bio/organic manure for improving soil-fertility and is free from weed-seeds, foul smell and pathogens. The slurry is rich in primary nutrients such as nitrogen, potassium and sodium (NPK) along with micronutrients - iron and zinc etc. The field trials have indicated excellent growth in agro-production and substantial improvements in quality. This biogas bottling project will be able to replace fuel and manure worth about Rs. 35 lakh annually. The full cost of the project would be recovered within four to six years. The separation and bottling of CO_2 and extraction of humic acid from slurry would further improve viability of biogas bottling plants.

BIOGAS DIGESTER

Different types of high rate bio-methanation digester viz. Upflow Sludge Anaerobic Blanket (USAB), Modified USAB, BARC-NISARGRUNA, Induced Bed Reactor (IBR) and Continuous Stirred-Tank Reactor (CSTR) etc. were installed in various parts of country under technology demonstration of biogas bottling.

BIOGAS PURIFICATION TECHNOLOGY

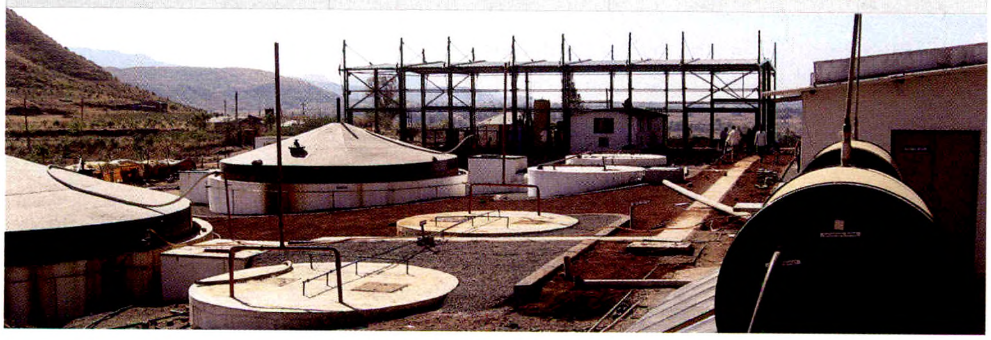
Different types of biogas purification technology such as water scrubbing - using low or high pressure and pressure swing adsorption (PSA) - were installed in the country for purification of biogas. All required statutory clearances / permissions have to be obtained by promoters from the concerned authorities.

INDIAN STANDARD ON BIOGAS (BIOMETHANE)

Bureau of Indian Standards (BIS) has prepared Indian Standard on biogas (biomethane) – specification (IS 16087:2013) on the request of MNRE and the same has been published. The biogas (biomethane) for automotive application and piped network shall also comply with the requirements given in Table 1, when tested in accordance with the methods given in table 1 column 4. This biogas (biomethane) may also be used for applications such as stationary engines or power generators.

TABLE 1: Requirements for Biogas (Biomethane)

CHARACTERISTIC	REQUIREMENTS	METHOD OF TEST, REF TO.
CH_4, Percent, Min	90	IS 15130 (Part 3) : 2002
Moisture, mg/m^3 Max	16	IS15641 (Part 2) : 2006
H_2S, mg/m^3 Max	30.3	ISO 6326-3 : 1989
$CO_2+N_2+O_2$, Percent, Max (v/v)	10	IS15130 (Part 3) : 2002
CO_2, Percent, Max (v/v), (When intended for filling in cylinders)	4	IS15130 (Part 3) : 2002
O_2, Percent, Max (v/v)	0.5	IS15130 (Part 3) : 2002



INTERNATIONAL WORK AT ISO

At the international level, Institutional Organization for Standardization (ISO) is formulating standards on biogas through its committee TC 255- Biogas (anaerobic digestion, AD) with the secretariat at standardisation administration of China (SAC, China). India is a participating member on this Committee.

CONCLUSION

Biogas bottling plants are one of the most potent tools for mitigating climate change. The purified biogas can be bottled in CNG cylinders and wherever CNG is currently used, compressed biogas (CBG) can provide a better and safer alternative. There is a vast potential for the production of biogas in the country. In addition to the energy production, biogas plants also provide bio-manure and are help in dealing with the problems of waste management, providing clean environment and mitigating pollution in urban, industrial and rural areas. Biogas is also a prominent alternative to petroleum fuel like LPG, CNG and diesel. Therefore, it is highly desirable to promote biogas bottling plants and R&D activities for further development in the country. ✪

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ASIAN COUNTRY PROFILE

The January 2013 'Renewable energy country profile' report of the International Renewable Energy Agency (IRENA) gives an overview of the status of renewable energy in each country with details about energy supply, electrical generation and grid capacity and access.

INTERNATIONAL
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First session of the Assem
PRESIDENT

First session of the International Renewable Energy Agency Assembly

The energy statistics provided in the International Renewable Energy Agency (IRENA) report, released in January 2013, span from 2009 to 2012 with the latest available data. The statistics are compiled by IRENA's specialists from available country data and additional information from a variety of sources like the International Energy Agency, World Bank, World Trade Organisation, United Nations, United Nations Framework Convention on Climate Change etc. The report profiles 29 Asian countries including India.

The Report gives an overview of the status of renewable energy in each country with details about energy supply, electrical generation and grid capacity, and access. Energy policies, targets and projects are also considered, along with each country's investment climate and endowment with renewable energy resources. The Report is a starting point for a series of reports on individual countries.

INDIA

The per capita consumption of electricity in India, which has a population of 1,170.9 million, was 617 kWh. In the same year the per capita consumption for South Asia was 540 kWh, for Asia was 1,755 kWh and it was 2,728 kWh for the world. In 2009, 26.5 per cent of the 28,269.1 PJ total primary energy supply, 13.7 per cent of the 906.8 TWh of electricity generation and 27.9 per cent of 189.3 GW electricity capacity came from renewables. All the sources of renewable energy – solar, wind, hydro, geothermal, biomass and ocean, made a 'high' contribution to the energy profile.

FIG. 1: Electricity Use Per Capita for 2009

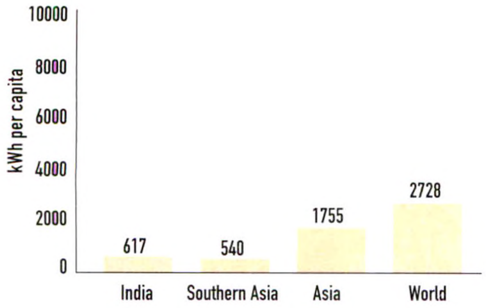
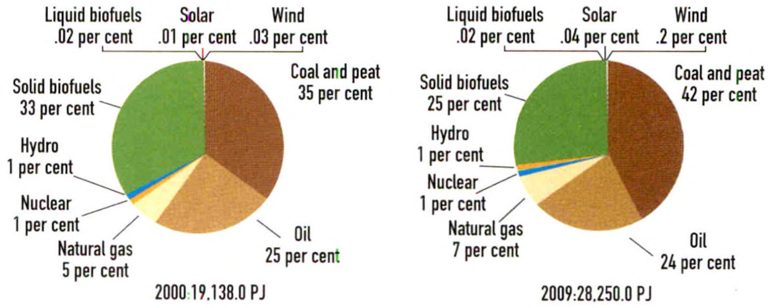


FIG. 2: Total Primary Energy Supply* in 2000 and 2009



*excluding electricity trade

BRUNEI DARUSSALAM

Brunei Darussalam, the second least populated country in Asia (399,000), has the highest per capita consumption of electricity at 8652 kWh. However, renewables did not play any part in the energy profile of Brunei Darrusalam in 2009. The country has set a target of reaching 10 per cent electricity generation from renewables by 2035. It did not have any policies for renewable energy before 2011.

FIG. 3: Electricity Use Per Capita for 2009

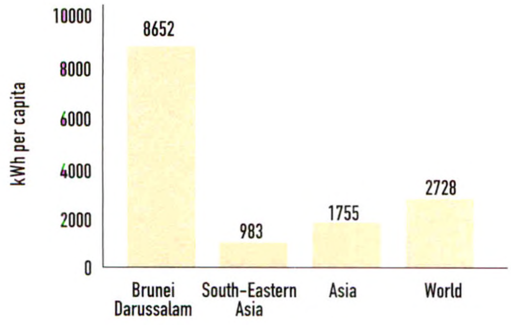
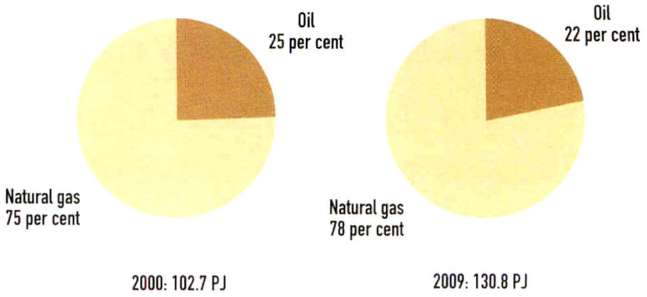


FIG. 4: Total Primary Energy Supply* in 2000 and 2009



*excluding electricity trade

AFGHANISTAN

Afghanistan, with a population of 34.4 million, has the lowest per capita consumption of electricity – 49 kWh. In 2009, 30.2 per cent of total primary energy supply, 82.6 per cent of electricity generation and 76.5 of electrical capacity came from renewables. The Report does not contain any data on targets for role of renewables. There is 'high' contribution from solar, hydro and geothermal energy sources; and, none from the ocean. Afghanistan started devising policies for renewable energy in 2006.

FIG. 5: Electricity Use Per Capita for 2009

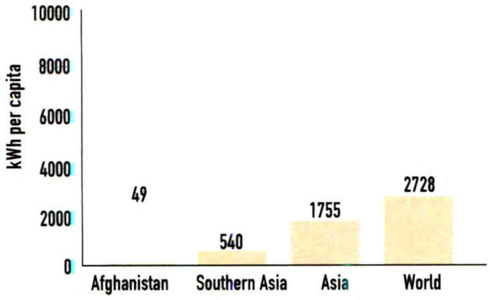
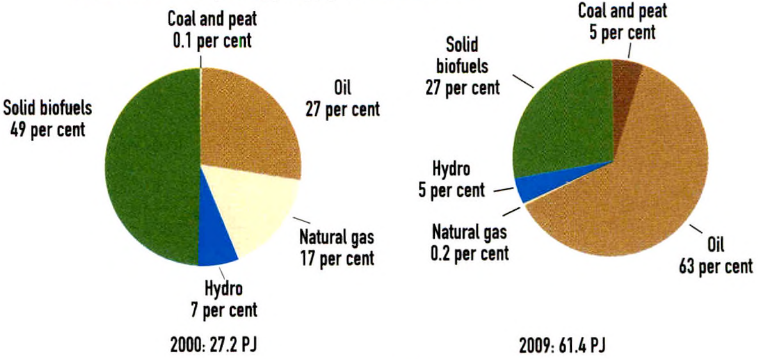


FIG. 6: Total Primary Energy Supply* in 2000 and 2009



*excluding electricity trade

MALDIVES

Maldives, the least populated country in Asia (316,000) reported 2283 kWh per capita consumption. Renewables played a negligible part in the energy profile of Maldives in 2009, with solar being the biggest contributor. Maldives hopes to generate 50 per cent electricity from renewables by 2015; 60 per cent electricity from solar by 2020; and carbon neutrality in the energy sector by 2020. Solar is the highest contributor to the energy profile. Policy interventions for renewable energy began in 2004.

FIG. 7: Electricity Use Per Capita for 2009

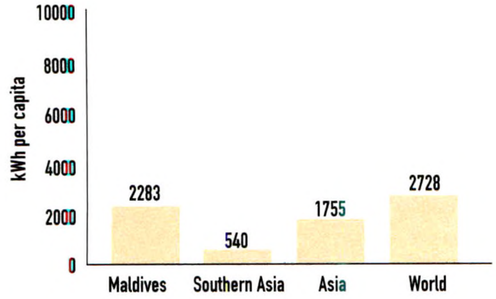
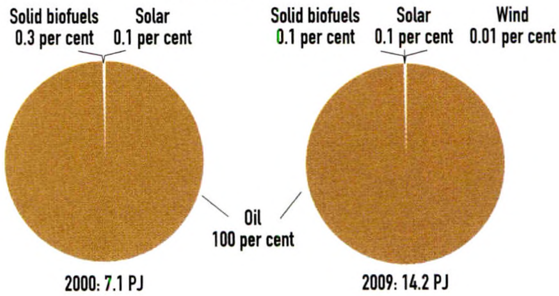


FIG. 8: Total Primary Energy Supply* in 2000 and 2009



*excluding electricity trade

CHINA

China, with a population of 1,345.4 million, the most populated country in the world, has a per capita consumption of 2,650 kWh. In 2009 11.9 per cent of the total primary energy supply, 17.1 per cent of electricity generation, 24.3 of electricity capacity came from renewables. The contribution of renewable sources in energy production is 'high'. China has had policies to promote renewable energy since the Rio Conference, beginning with the Brightness Programme in 1996. ✪

FIG. 9: Electricity Use Per Capita for 2009

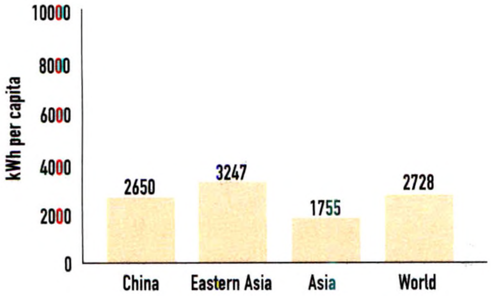
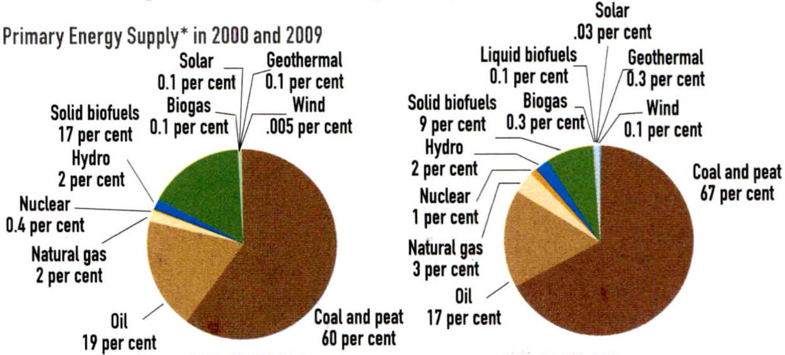


FIG. 10: Total Primary Energy Supply* in 2000 and 2009



*excluding electricity trade

HEAT PUMPS

Heat pumps for heating and cooling were first commercialised in the second half of the 20th century, but applications in cold climates were limited to ground-source heat pumps because of the low temperatures of outdoor air.

Today's air-source heat pumps are able to supply heat even with outside air temperatures of -25°C. The market share of heat pumps for both heating and cooling applications is growing rapidly due to improved performance in terms of energy efficiency and CO_2 emissions in the residential, commercial and industrial sectors.

PROCESS AND TECHNOLOGY STATUS

The physics of heat pumps is well-known. While heat (thermal energy) tends to flow naturally from high-temperature sources to low-temperature heat sinks, heat pumps can move heat from low-temperature to high-temperature heat sinks. The heat pump principle is based on the four phases of the reverse Carnot cycle. Therefore, a heat pump can typically be used to extract heat from a refrigerator or an air-conditioner and provide heat for water or space heating.

The basic configuration of a heat pump consists of the evaporator (i.e. outdoor unit) where the process fluid evaporates, absorbing heat from the heat source (e.g. air), a compressor to compress the fluid and increase its temperature, a condenser (i.e. indoor unit), which releases heat by condensing, and an expansion valve to reduce the pressure and temperature of the process fluid to below the level of outside air temperatures in order to restart the cycle. The energy for the process is provided by the electric energy to run the compressor and circulate the fluid.

Heat pumps are highly efficient devices, as they can move and supply six units of thermal energy for each unit of electrical energy consumed. The ratio of the thermal energy provided for space cooling or heating to the energy consumed is the heat pump's coefficient of performance (COP), one of the heat pump performance indicators. Another performance indicator for heat pumps is the seasonal performance factor. Because definitions of heat pumps' energy performance differ between Asia, North America and Europe, the International Organisation for Standardisation (ISO) is working to define a global standard - the annual performance factor (APF) - which is the ratio of the total amount of heat, the device can remove from, or add to, space concerned during the cooling and heating seasons (respectively) to the total amount of energy consumed for both heating and cooling services. The high efficiency of heat pumps can provide advantages in terms of energy and CO_2 emissions, saving in comparison to other approaches (e.g. combustion) to space/water heating and cooling.

As a primary heat/cold source and sink, heat pumps can use outdoor air, river/lake/sea water or even ground (underground) heat and cold. All these sources can be regarded as renewable heat/cold sources, which can be used for residential, commercial and industrial applications. There may be, for example, air-to-air or air-to-water heat pumps or even water-to-air and ground-to-water/air heat pumps. The efficiency of heat pumps based on water sources is generally high because surface water is usually colder than air when space cooling is needed (e.g. summer) and warmer than air when space heating is needed (e.g. night time, winter). Of course, heat pumps can also use all kinds of waste heat, such as industrial and residential waste heat, or heat from sewage treatment.

In cold climates, their use has been limited to ground-source heat pumps as the outside air temperature is too low for using air-to-air heat pumps. However, more recent air-source heat pumps are able to supply heat even with outside air temperatures of -25°C, using injection circuits which bypass the evaporator and inject fluid into the compressor for cooling during compression or two-stage compression to increase fluid circulation volume. Freezing risks have been prevented by passing hot-leg fluid through the colder part of the heat exchanger in the outdoor units. The time needed for defrosting and from start-up to blow-off of heated air has also been shortened. These component technologies have significantly contributed to improving the space heating performance and efficiency of heat pumps. All these improvements have enabled the use of air-source heat pumps in cold climates for applications to space heating, floor heating, water heating and even road heating for snow melting.

In some cases, thermal storage systems are used to increase the efficiency of heat pumps and reduce peak power demand for buildings. These systems typically consist of a thermal storage tank where the heat produced overnight is stored and used during the day. Various thermal storage media have come into practical use. Chilled and hot water storage is used in thermal storage systems for heat pump air-conditioning systems. More recently, air-conditioning systems with ice-based, latent heat storage (and small-size storage tanks) have been developed. Also, air-conditioning systems with thermal storage based on the building body and no storage tank have come into practical use.

HEAT PUMPS ARE HIGHLY EFFICIENT DEVICES, AS THEY CAN MOVE AND SUPPLY SIX UNITS OF THERMAL ENERGY FOR EACH UNIT OF ELECTRICAL ENERGY CONSUMED.

PERFORMANCE AND COSTS

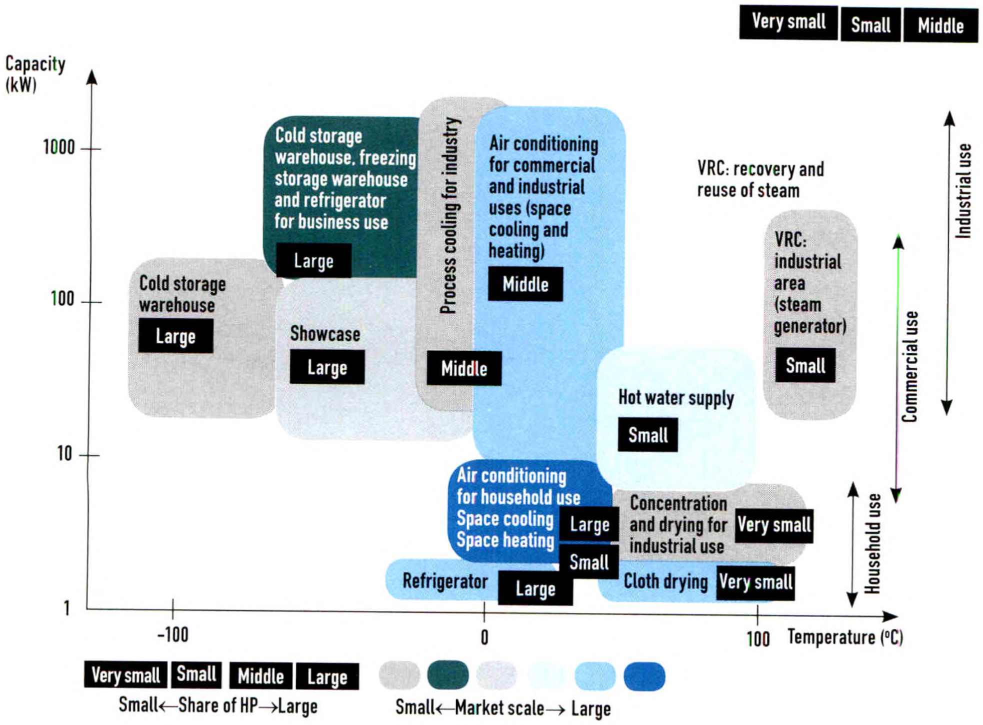
Heat pumps can provide three to six units of useful thermal energy for each unit of energy consumed, whereas traditional combustion-based heating systems only provide less than one unit of thermal energy for each unit of energy consumed. Today's best heat pumps can offer COP values between six and seven and a high reliability under a wide range of operating conditions. The heat pump's efficiency has increased substantially over the past years as a result of technical improvements and the use of inverters and control systems. Recently, the seasonal performance factor (SPF) (i.e. the ratio of heat delivered to the energy consumed over the season) of the most efficient, commercial heat pumps has reached the level of 6-7, although SPF varies considerably with the heat pump technology, heat source and operating conditions.

Ground-source heat pumps (GSHPs) can serve as effective systems for space cooling (summer) and heating (winter), as in most regions the ground temperature remains stable throughout the year (i.e. between 10-15°C). However, air-source heat pumps (ASHPs) are often the technology of choice for air-conditioning. The use of ASHPs is very cost-effective in regions where both space heating and cooling are required throughout the year. Most advanced devices can reach COP of higher than six.

POTENTIAL AND BARRIERS

Currently, space heating and cooling, together with hot-water supply, are estimated to account for roughly half of the global energy consumption in buildings. Most of this energy demand is met by combustion of fossil fuels with their related CO_2 emissions. Air-conditioning and cooling demand is growing, particularly in emerging economies. Heat pumps can reduce energy consumption and CO_2 emissions, as well as improve energy security. If combined with thermal storage, heat pumps can also reduce the

FIG. 1: Heat Pump Application Areas



demand for peak power. It has been estimated that widespread use of heat pumps for space heating/cooling and water heating in the commercial sectors could reduce CO_2 emissions by 1.25 billion tonnes by 2050.

Major barriers to the widespread use of heat pumps include the insufficient recognition of benefits and the high investment costs. Defining international standards for heat pump efficiency, as well as labelling and providing incentives (e.g. subsidies, grants) for heat pump use, could help overcome these barriers. The use of heat pumps would be greatly encouraged if the thermal energy they captured were recognised worldwide as a renewable energy source. As for performance and costs, current R&D activities are expected to increase efficiency by 40-60 per cent for heating services and by 30-50 per cent for cooling services, and to reduce costs by 30-40 per cent and 5-20 per cent, respectively, by 2050.

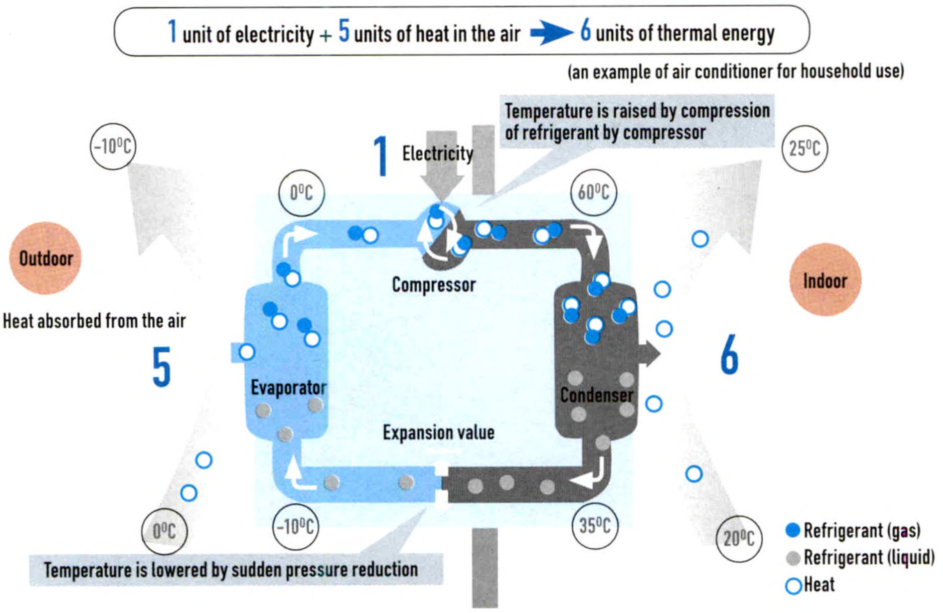
Heat pumps are considered as a renewable energy technology in the European Union (EU), where they are expected to account for between 5 per cent and 20 per cent of the EU's renewable energy target for 2020. Several other countries (e.g. the United States, the United Kingdom, Australia and Japan) grant tax reductions, subsidies or other benefits to facilitate the use of heat pumps. In many other countries however, heat pumps are not considered as renewable technologies and receive no incentives or subsidies. In addition, because significant differences exist in national standards and regulations to measure heat pump performance, their contribution to the penetration of renewable energy is not well captured in today's energy statistics. To support heat pump deployment, national standards should be harmonised, consumers should be fully informed of the efficiency of heat pumps, and the investment costs of heat pumps

SEVERAL COUNTRIES GRANT TAX REDUCTIONS, SUBSIDIES OR OTHER BENEFITS TO FACILITATE THE USE OF HEAT PUMPS. BUT IN MANY OTHERS IT IS NOT CONSIDERED AS RENEWABLE TECHNOLOGIES AND RECEIVE NO INCENTIVES OR SUBSIDIES.

TABLE 1: Typical Cost of Heat Pumps for Residential Space Heating/Cooling and Hot Water Supply

REGIONS		NORTH AMERICA	CHINA AND INDIA	OECD PACIFIC	OECD EUROPE
Typical size (kW)		2-19	1.5-4	2.2-10	2-15
Economic life (year)		15-20	15-20	8-30	7-30
Installed Cost (USD/kW)	A to A	360-625	180-225	400-536	588-1430
	ASHP	475-650	300-400	560-1333	607-3187
	GSHP	500-850	439-600	1000-4000	1170-2267

FIG. 2: Mechanism of Heat Pump


1 unit of electricity + 5 units of heat in the air → 6 units of thermal energy
(an example of air conditioner for household use)
Temperature is raised by compression of refrigerant by compressor
1 Electricity
-10°C
0°C
60°C
25°C
Outdoor
Compressor
Indoor
Heat absorbed from the air
5
Evaporator
6
Condenser
Expansion value
0°C
-10°C
35°C
20°C
Temperature is lowered by sudden pressure reduction
● Refrigerant (gas)
● Refrigerant (liquid)
○ Heat

(compared to traditional combustion devices) should be reduced. Therefore, continued support to R&D and policy measures are essential to improve competitiveness and market penetration of heat pumps, thus exploiting their large potential to supply efficient and clean energy services.

APPLICATION

Common applications for heat pumps are air-conditioning, refrigeration and space heating in both residential and commercial buildings. Other applications include hot water supply in commercial buildings, cold storage warehouses and process heat and steam for industrial applications.

With capacities between 1kW and 10 MW, current heat pumps can provide heating and cooling to single houses or to entire districts. In industrial applications, they can be used at temperatures from below -100°C to above 100°C. ✪

Inputs from IEA-ETSAP and IRENA technology brief E-12 – 2013

RENEWABLES

India Trade Promotion Organisation organised the 33rd edition of its popular annual event, the India International Trade Fair, at Pragati Maidan, New Delhi from 14 to 27 November, 2013, where the exhibition of the Ministry of New and Renewable Energy proved to be a crowd puller with hundreds visiting it on a daily basis.

AT IITF 2013

MNRE

India's International Trade Fair is the largest integrated trade fair with business-to-business and business to consumer components. It presents a complete range of products from diverse sectors from major manufacturers to small and medium enterprises. It has a large participation of international exhibitors. It is one of the largest trade fairs in the world both in terms of exhibitors and visitors' participation and has evolved its unique character as an iconic national event.

The Ministry of New and Renewable Energy's (MNRE) stall put up at the International Trade Fair became a centre of attraction during the exhibition. The stall was used to disseminate information on new and commercially successful methods of generating renewable energy. Its allied benefit to the environment was also outlined. Live demonstrations were staged that generated a lot of interest among the young and the old, alike. Many asked about the locations and listing of Akshay Urja shops and outlets where appliances could be purchased. Relevant brochures and materials were handed over to interested persons. With a persistent yearly increase in development of renewable energy the interest in the sector was palpable. A lot of industries dealing with renewable energy also made their presence felt at the Trade Fair 2013. Over half a million people visited the MNRE Pavilion in India International Trade Fair. The display of various renewable energy systems and equipment were the major attraction for the people. Many people booked the solar water heater at the exhibition. Many dignitaries visited the MNRE Pavilion. The MNRE is the nodal agency in the country on matters related to renewable energy and has incorporated the latter as an essential component of India's energy policies.

CHANGE IN MINDSET

MAKES CHANDIGARH A MODEL SOLAR CITY

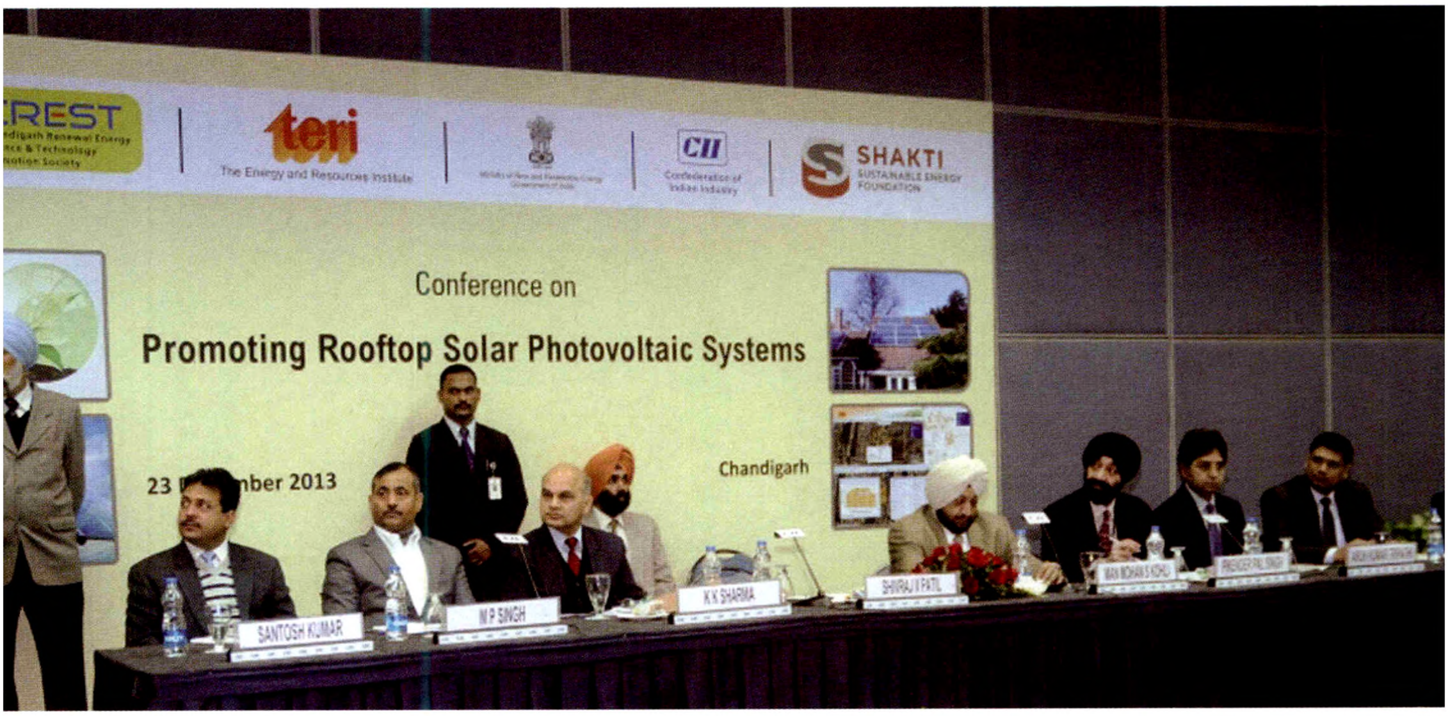
A Conference titled 'Promoting Rooftop Solar PV Systems' held on 23rd December 2013 at CII, Chandigarh, aimed to bring together all key stakeholders to deliberate on how to create a power surplus environment for a sustainable future.

HE Mr Shivraj V Patil said, "Chandigarh, which has been ideally chosen as the Model Solar City by the Government of India has the potential to reach the ambitious target of solar energy production in next few years.

"Adoption of latest solar technologies, indigenous production of hi-tech solar photovoltaic (PV) panels and more efficient solar equipment, and most importantly, its acceptance by citizens, institutes and industry by aggressive promotion campaigns is the key to make Chandigarh a model solar city", highlighted HE Mr Shivraj V Patil, Governor, Punjab and Administrator, UT Chandigarh, while addressing the Conference on Promoting Rooftop Solar Photovoltaic Systems in India organized by the Chandigarh Renewable Energy, Science and Technology Promotion Society (CREST), Confederation of Indian Industry (CII), Ministry of New and Renewable Energy (MNRE), GoI, The Energy and Resources Institute (TERI) and Shakti Sustainable Energy Foundation (SSEF) at CII Northern region headquarters at Chandigarh, on 23rd December 2013.

He further said that "Chandigarh, which has been chosen as the Model Solar City by the Government of India has potential to reach the ambitious target of solar energy production in the next few years. The industry can capitalise on this and earn huge profits, because this is the energy of the future, being un-polluting and absolutely free, once the capital investment is put in. Even residents can earn profits by supplying excess energy back to the grid, simply by putting up solar panels on their roof tops. What is imperative is the sound popularisation, promotion and large scale domestic production of the same to achieve benefits of 'economies of scale'. As the prices fall, we won't need to import the panels from other countries and save a lot of forex reserves as well. Even financial institutions and banks can be collaborated with to generate funds for the same."

"We would provide income tax concessions and also plead with the Centre for incentives to those who invest in R&D and adopt innovative technologies in this field." He exhorted that he does not agree with those who say that the whole world is going to face an energy crisis in future due to its fast growing demand. He said that he is sure that mankind will find answer to such demand through innovations. What is required are the efforts to convert it in useful forms.


CREST
teri
The Energy and Resources Institute
CII
Confederation of Indian Industry
SHAKTI
SUSTAINABLE ENERGY FOUNDATION
Conference on
Promoting Rooftop Solar Photovoltaic Systems
23 ber 2013
Chandigarh
SANTOSH KUMAR
M P SINGH
K K SHARMA
SHIVRAJ V PATIL

The Conference aimed to bring together all key stakeholders to create a power surplus sustainable future and also to pre launch the web-based GIS tool being created by TERI especially for Chandigarh as a pilot project, which would calculate the estimated rooftop potential of any individual roof as well as that for the entire city. The residents can just click the link and check the rooftop SPV potential of their respective homes. This shall also provide data on solar radiation available throughout the year on the roof, expected capacity of SPV plant that can be installed and expected electricity generation for the year from that particular roof. The link is – www.regisindia.com. This shall be available free of cost to any person.

Mr K K Sharma, IAS, Advisor to Administrator, UT Chandigarh, said "Technical-scientific expertise and capital investments are needed to make Chandigarh a model solar city. We would take utmost care of the metering and incentive issues. Also, the industry needs to improve its supply chain management and production techniques."

He also informed that the Chandigarh Administration is planning to implement a sound and effective single-window system for solar projects and rooftop applications. "Now, to claim subsidy, residents do not have to visit the Government of India offices and it can be availed at CREST level". He informed that besides installing grid tied rooftop SPV plants at various government offices/schools/colleges, the UT Administration has installed "rooftop SPV plants of 2 kW capacity each at five government residential houses as demonstration project which shall be a trend setting example".

Mr Santosh Kumar, Director, Science & Technology, Chandigarh & CEO, CREST informed that CREST is going to launch new scheme for residents of Chandigarh where they can install smaller capacity SPV plants of 1kW, 2 kW, 3 kW, 5 kW capacity etc., on their rooftop and can avail 30 per cent subsidy of MNRE at local CREST level itself. He also informed that the residents who already have an inverter and battery system can just retrofit their existing system with solar panel and charge controller to use solar energy by spending Rs. 25,000 only. "In order to achieve grid parity by 2015, we need to adopt sustainable power generation methods at large-scale and rooftop solar PV systems will be a new boon in this field. ," he added. ✪

SOLAR THERMAL AWARD FUNCTION

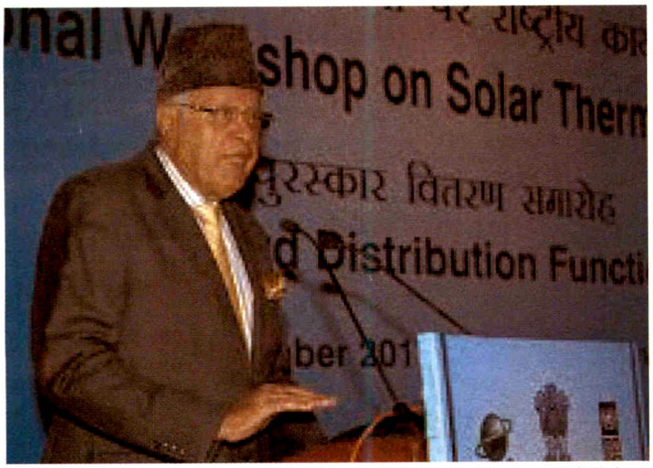
A total of 28 awards were distributed in the function held on 17th December 2013 which included awards to state nodal agencies, beneficiaries and channel partners of the Ministry.

« The Union Minister for New and Renewable Energy, Dr. Farooq Abdullah releasing the knowledge documents developed under UNDP-GEF Project on concentrating solar heat (CSH), in New Delhi on December 17, 2013.

Minister of New and Renewable Energy (MNRE) Dr. Farooq Abdullah highlighted the need for greater propagation of solar water heating system on the occasion of the Award distribution function on Solar Thermal Systems in New Delhi on 17th December 2013. Dr. Farooq Abdullah said that solar water heating can save a tremendous amount of energy. He emphasized the need for having more number of sale and service professionals/entrepreneurs in this area so that people have access to renewable sources of energy. He exuded confidence that the target of generating 20,000 MW through the Jawaharlal Nehru National Solar Mission (JNNSM) by the year 2022 would be achieved.

A total of 28 awards were distributed which included awards to state nodal agencies (SNAs), beneficiaries and channel partners of the Ministry. The award for the first position among SNA for the category of 'Solar Water Heating Systems' (SWHS) was given to Gujarat Energy Development Agency, Gandhinagar. The award for the first position among SNAs for the category of 'Solar Water Heating Systems' relating to percentage increase in is installation was given to Ladakh Renewable Energy Development Agency, Ladakh. Best website on Solar Water Heating System Award was given to National Informatics Centre (NIC), Ministry of Communication and Information Technology. Best SNA for use of Dish Solar Cookers and the award for highest number of SWHS installations in special category states was given to Uttarakhand Renewable Energy Development Agency, Dehradun. Kargil Renewable Energy Development Agency (KREDA), Kargil-Ladakh (J&K) was awarded Best SNA for largest installation of domestic green houses for the purpose of growing vegetables in extreme climatic conditions for the year 2012-13.

Earlier, Dr. Farooq Abdullah also released two knowledge documents developed by the Ministry in partnership with


Minister of New and Renewable Energy (MNRE) Dr. Farooq Abdullah, delivering the speech.

UNDP-GEF that includes success stories and video films on installations, fliers on concentrating solar technologies (CST) and a compendium of such technologies available.

Till date, 7.37 million sq meters have been installed. The factors influencing SWHS growth are capital subsidy under JNNSM policy, United Nations Development Programme (UNDP) project, state/city level regulations, for mandatory use of SWHS in certain sector, primarily in domestic and institutional sector. State governments are required to bring out GO/regulation in this sector. State wise installation is as follows:

- Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Kerala – 80.5 per cent.
- Rajasthan, Madhya Pradesh, Chhatisgarh, Jharkhand, Odisha – 6.4 per cent.
- Haryana, Punjab, Uttar Pradesh, NCR, Bihar, West Bengal – 11.6 per cent
- Jammu & Kashmir, Himachal Pradesh, Uttarakhand – 1 per cent.
- NE region – 0.4 per cent.

Of all the installations approximately 87 per cent installations are in residential sector, 2 per cent in hotels, 1 per cent in hospitals and industries each, in others 9 per cent. One good example coming up is Malkapur Nagar Panchayat, Maharashtra where 6000 houses will have SWHS and solar PV in place in association with NABARD and MNRE.

Till date 28000 square meter CST systems have been installed at Shirdi Brahmakumaris Ashram, Mount Abu; Art of Living, Bangalore; Shanti Kunj, Haridwar; and Srigeri Matth, near Bangalore; apart from various universities and college hostels. For cooling and laundry applications CSTs have been provided at places like Civil Hospital, Thane near Mumbai; Cancer Hospital, Muni Sewa Ashram near Vadodara; ITC Maurya, Delhi; Mahindra & Mahindra, Pune; and Gajraj Cleaners, Ahmednagar, Maharashtra.

IREDA MARKS ROBUST PERFORMANCE

Indian Renewable Energy Development Agency Limited (IREDA), a Government of India Enterprise under Ministry of New and Renewable' Energy (MNRE) is a unique financial, institution dedicated for financing renewable energy and energy efficiency projects. IREDA has been spearheading the development of renewable energy projects in the country which has one of the highest levels of renewable energy deployment in the world.

During the financial year 2012-13, IREDA posted robust performance with an all-time high Profit before Tax (PBT) at Rs. 250.58 crores registering a 20.40 per cent rise over the previous fiscal and recorded its profit after tax of Rs. 202.65 crores compared to Rs. 173.13 crores over the previous fiscal. Loan sanctions and disbursement during the year 2012-13 stood at Rs. 3747.36 crores and Rs. 2125.50 crores respectively which is an increase of 10.02 per cent in sanctions and 14.58 per cent in disbursement as compared to the last year. IREDA presented a cheque of Rs. 27.50 crores towards dividend for FY 2012-13 representing an increase of 10 per cent as compared to last year. The dividend cheque was presented by Shri Debashish Majumdar, (CMD, IREDA) to Dr. Farooq Abdullah, Hon'ble Union Minister for New and Renewable Energy in the presence of Shri Ratan P. Watal, Secretary, MNRE and other senior officials of MNRE and IREDA on 14th November 2013 at New Delhi.

WIND TURBINES IN EXTREME WEATHER CONDITIONS

Current design standards do not cover extreme weather conditions, such as hurricanes, cyclones and typhoons, leading to complications for designers and wind turbine manufacturers who build wind projects in cyclone-prone areas.

Current design standards for wind turbines take into account short term extreme wind events but prolonged wind conditions experienced in tropical storms are not covered. Therefore guidelines for wind turbines in extreme conditions have been developed. The fact that design standards do not cover extreme weather conditions, such as hurricanes, cyclones and typhoons, provides complications for designers and wind turbine manufacturers who build wind projects in cyclone-prone areas. Therefore, guidelines to access the wind condition and wind turbine and safety related aspects when exposed to conditions experienced during such extreme weather are extremely pertinent.

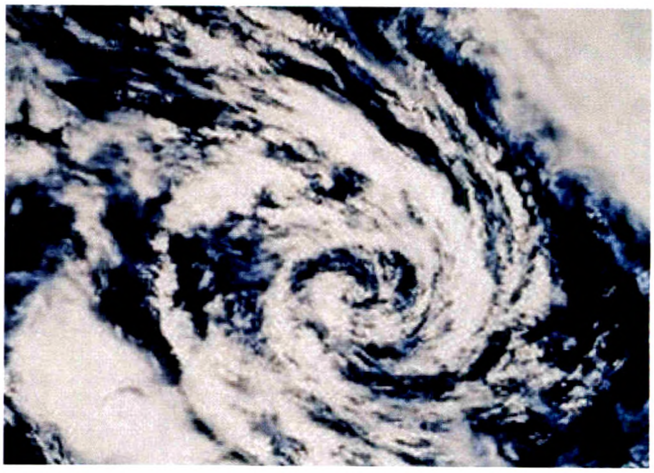
Continuing the work from an initial 2011 innovation project, this year's effort (by DNV Clean technology Center, Singapore and DNV KEMA, Denmark) focused on the content and structure of the guidelines for wind turbines in extreme conditions. The project consists of:

- Developing the methodology of analysing tropical cyclones;
- Developing the recommended practice (RP) structure for wind turbines in extreme conditions;
- Gap analysis of missing sections in the RP
- Refining the probabilistic wind analysis methodology which uses historical hurricane track data in order to calculate the probability that a hurricane of a certain category would affect the site.

A comparison between current design load cases in the IEC standard is also reviewed, to identify if it is applicable to the wind conditions experienced in a tropical storm event.

This project develops the framework and content for the RP. A good understanding on the gap in present practices and standards is required. Further research is required to develop this into a recommended practice that would allow developers, owners to evaluate the risk of having the project in a tropical cyclone-prone region.

Manufacturers and designers would also be able to take into consideration such extreme wind conditions when designing a wind farm located in the vicinity of such events.



Wind turbines in extreme weather conditions

The methodology for performing a probabilistic typhoon analysis uses the best track data from met offices worldwide. Comparisons of the current guidelines and standards are made and gaps identified between the design codes and extreme events. The creation of new design load cases is envisaged for future research.

In addition, identification of additional components that would reduce the impact from such extreme events, e.g. having a backup generator in place for turbines to ensure that yaw motion is possible in the event of grid disruption; and, using a pin-locked mechanical fixture, compared to a brake disc may be preferred due to potential wear and tear of using a brake disc; etc.

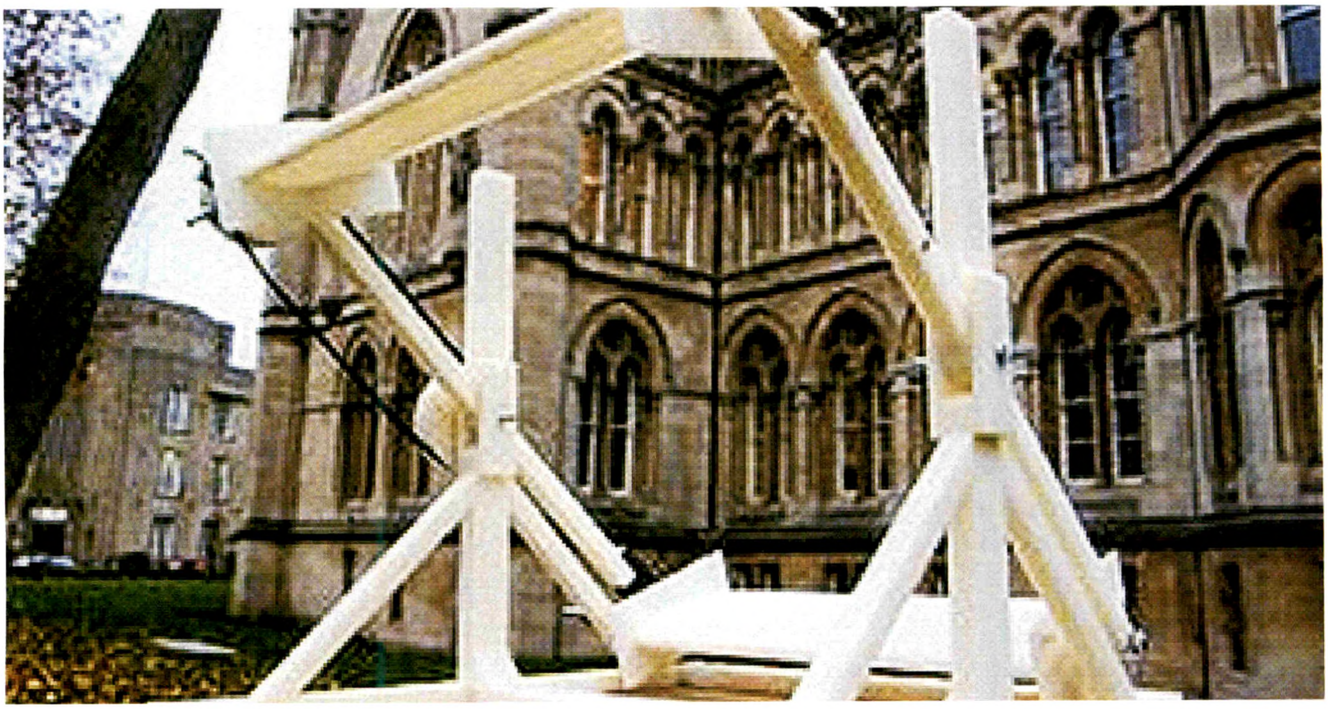
Benefits

- Better understanding of wind characteristics involved during tropical storms
- Able to help client understand the risk of having the wind farm near to these typhoon/cyclone-prone regions
- Development of a recommended practice in analysing wind turbines in extreme conditions
- Display thought leadership in the wind industry.

Inputs from: dnvgl.com

NEW STYLE TURBINE TO HARVEST WIND ENERGY

With blades of initially just one metre, the Wind Harvester has the potential for both commercial and domestic use.



The Wind Harvester has potential for both commercial and domestic use

The Wind Harvester, a small, more efficient turbine, is being developed by Heath Evdemon, founder of Wind Power Innovations Ltd, with the help of Future Factory, the Nottingham Trent University's sustainable design project.

The Wind Harvester would be able to make power from low and high wind speeds, unlike current turbines. Most traditional three-blade turbines generate energy from wind speeds between about 30mph to 50mph. A large scale fully working model is expected to be installed in the Derbyshire Peak District (where and when). A new way of generating wind energy which could see smaller, more efficient turbines on the landscape is being developed by a Derbyshire inventor

With blades of initially just one metre, the Wind Harvester has potential for both commercial and domestic use. Traditional wind turbines typically have three blades which rotate around a horizontal hub at the top of a steel tower. Most generate maximum output at an approximate wind speed of 30mph and shut down to prevent storm damage at 50mph or above, causing reduced efficiency of some turbines. The new Wind Harvester is based on reciprocating motion that uses horizontal aerofoils similar to those used on aeroplanes. It is virtually noise-free and can generate electricity at a low speed, which may result in less opposition to new installations. It will also be operational at higher wind speeds than current wind turbines.

It can be made in any size up to approximately 15 metres across and only needs to be approximately half a metre off the ground in prominent positions such as hills and hillsides, rock outcrops, and on domestic, farm and industrial buildings and structures. All sizes can be broken down into handleable pieces so installation will not require the use of heavy machinery, which is particularly relevant to environmentally sensitive areas.

Inputs from ntu.ac.uk (Nottingham Trent University)

GREEN PRODUCTS

DuraTrack™ HZLA solar tracker

Up to 25 per cent more power from existing PV systems by using the DuraTrack™ HZLA* - claims its manufacturer. This single-axis tracker uses a single drive and motor to move all modules from East to West, following the sun from sunrise to sunset to maximize power production.

FLEXIBLE SYSTEM

The multiple DuraTrack HZLA trackers laid out in long or short rows to fit the property's shape and the HZLA's design reduces shading when adding additional trackers to increase system size.

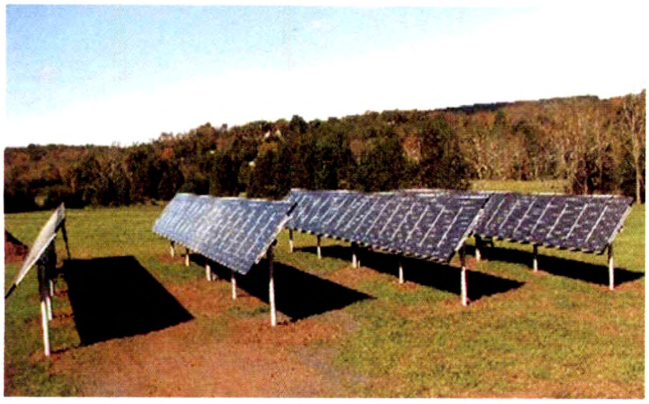
FAST AND EASY TO INSTALL

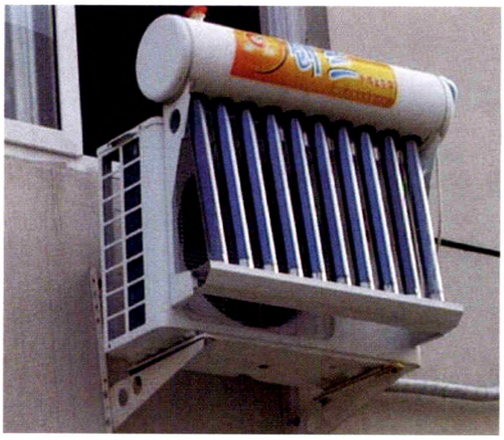
The manufacturers assert that a universal mounting system accommodates almost any type of module and DuraTrack™ high-speed mounting clamps make installation fast. The DuraTrack HZLA requires only commonly available materials for its foundation and columns.

STURDY AND RELIABLE

The company also claims that the DuraTrack HZLA is built of galvanized steel and anodized aluminium components to last longer. It adds that the DuraTrack HZLA is rated to 90mph wind loading and has been proven to stand up to high winds and harsh environments while providing maximum efficiency. The company also highlights that it is low maintenance as the dry-slide bearings require no lubrication.

Source - RenewableEnergyWorld.com





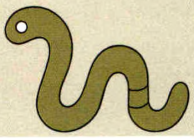
SOLAR AIR CONDITIONER

This hybrid solar air conditioner is designed for low cost, easy installation and fast payback. The solar air conditioning technology requires no batteries, no inverter, no controller - just plug in the solar panels and start saving up to more than 80 per cent on daytime cooling or heating costs. During the day it runs primarily on solar power and only uses small amounts of power from the utility company as needed. Hybrid operation eliminates the need for batteries and allows 24 hour per day use of the system. The system primarily uses solar power, adding normal AC power.

For home or office use, this system can cool an area with 80 per cent or more of the energy coming from sunlight. In addition to cooling, the GEI-HY-12 H/C solar heat pump can provide solar powered heating, operating all the way down to an outside ambient temperature of 5 degrees F. The GEI-HY-12 H/C solar air conditioner needs no batteries, and only need two or three PV panels to obtain huge savings. During the day, when air conditioning is needed the most, you can operate this unit with very little draw on your utility meter. At night, one can continue to save due to the >SEER 19 rating on this unit. And because it is a ductless system, it allows 100 per cent of heating or cooling to be delivered to where it is needed without the loss that occurs in a ducted system. However, this is not an "off-grid" unit; 220V utility power is required.

Source : www.geinnovations.net

WORDWORMS



Hidden amidst of maze of letters are terms that pertain to Renewable Energy. See if you can find all of them. Best of Luck.

B	I	O	M	A	S	S	A	I	N	A	A	L	O
S	A	B	C	D	O	F	G	H	I	K	L	E	N
G	B	D	B	D	L	F	G	F	I	S	L	D	N
E	C	B	I	D	A	F	G	U	I	H	L	M	S
O	D	M	O	D	R	E	N	E	W	A	B	L	E
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E	G	H	E	D	M	F	H	E	D	R	O	M	R
R	H	A	S	D	P	F	G	L	I	J	L	E	G
M	I	N	E	D	E	S	A	L	G	A	E	M	Y
A	L	E	L	D	E	F	G	H	I	K	L	C	M
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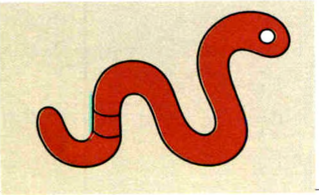


Answers : 1. Biomass; 2. Renewable; 3. Tidal; 4. Algae; 5. Photovoltaic; 6. Geothermal; 7. Methane; 8. Biodiesel; 9. Solar Lamp; 10. Fuel Cell; 11. Akshay Urja; 12. LED; 13. Energy;

Website

National Alternative Fuels Training Consortium

www.naftc.wvu.edu

A pioneer and national leader in developing, managing, and promoting programmes and activities that desire to cure America's addiction to oil, leading to energy independence, and encourage the greater use of cleaner transportation. The NAFTC is the only nationwide alternative fuel vehicle and advanced technology vehicle training organization in the United States.

Association for the Conservation of Energy

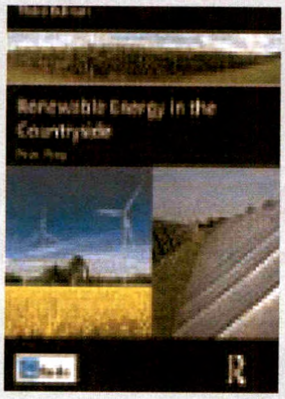
www.ukace.org

This association is formed by a number of major companies active within the energy conservation industry with an aim to encourage positive national awareness of the need for and benefits of energy conservation, to help establish a sensible and consistent national policy and programme, and to increase investment in all appropriate energy saving measures. The ukace.org site includes the sections on campaigns, articles, blogs and special area of the association's research group.

The Energy & Resources Organization

www.teriin.org

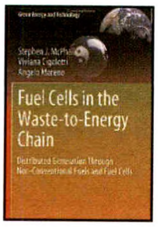
The web portal of this organization provides an insight into the events calendar, publications, projects and key research arenas of the organization. It provides creative, innovative ideas for the sustainable future to researchers and policy makers.



Renewable Energy in the Countryside

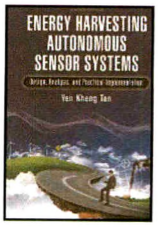
By **Peter Prag**
Hardcover: 144 pages
Cost: 130 USD
Publisher: Routledge; 3rd Edition (2013)
ISBN-10: 0415523974
ISBN-13: 978-0415523974

This is one of the few books which address renewable energy from the perspective of landowners, farmers and rural land managers – those people who must make important decisions about how, where and when to install renewable energy sources on their land and the business implications of the decisions they make. The third edition of Renewable Energy in the Countryside contains a new chapter on biogas, up-to-date discussions on the implications of Renewable Heat Initiative and new opportunities for solar energy and ground source heat in the context of farms and country houses.



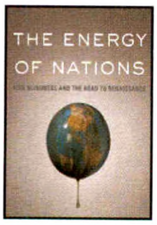
Fuel Cells in the Waste-to-Energy Chain: Distributed Generation Through Non-Conventional Fuels and Fuel Cells

By: Stephen J. McPhail, Viviana Cigolotti, Angelo M.
Hardcover: 232 pages
Cost: 129 USD
Publisher: Springer; 2012 edition (January 5, 2012)
ISBN-10: 1447123689
ISBN-13: 978-1447123682



Energy Harvesting Autonomous Sensor Systems: Design, Analysis, and Practical Implementation

By: Yen Kheng Tan
Hardcover: 254 pages
Cost: 139.95 USD
Publisher: CRC Press; 1 edition (January 29, 2013)
ISBN-10: 1439892733
ISBN-13: 978-1439892732



The Energy of Nations: Risk Blindness and the Road to Renaissance

By: Jeremy Legget
Paperback: 272 pages
Cost: 31.95 USD
Publisher: Routledge
ISBN-10: 0415857821
ISBN-13: 978-0415857826

Renewable: The World-Changing Power of Alternative Energy

By: Jeremy Shere
Hardcover: 304 pages
Cost: 25.99 USD
Publisher: St. Martin's Press
ISBN-10: 0312643756
ISBN-13: 978-0312643751

In India

9-10 January 2014	International Conference on Renewable Energy and Sustainable Development (ICRESD 2014), **Place:** Pune,India **Organiser:** KJEI's Trinity College, Pune **Website:** www.iset2014.com **Contact person:** G P Bharambe
16-18 January 2014	The GRIHA Summit 2014, **Place:** New Delhi, India, **Organiser:** Ministry of New & Renewable Energy, **Contact person:** Ms Priyanka Kochhar, **Website:**www.grihaindia.org
28-30 January 2014	4th International Conference on Solid Waste Management and Exhibition on Municipal Services, Clean technology **Place:** Hyderabad, Andhra Pradesh, **Organiser:** Govt. of Andhra Pradesh, Department of Municipal Administration and Urban Development, **Contact:** Dr. B. Janardhan Reddy - 91 40 23302150 **Website:** www.iswmaw.com
21-23 February 2014	International Conference on Renewable Energy (ICRE 2014) **Place:** Pune, India, **Organiser:** SAISE South Asia Institute of Science and Engineering, **Contact person:** Mr. Zeke Zhou Email: icre@saise.org, Tel:+86-27-86666663, **Website:** www.saise.org/icre2014

In Other Countries

14-15 January, 2014	4th Annual Electric Energy Storage Conference, **Place:** San Diego, CA, United States of America, **Organiser:** MARCUS EVANS, **Contact person:** Tyler Kelch, 312-540-3000 ext. 6680 Email: Tylerke@marcusevansch.com **Website:** www.marcusevans-conferences-northamerican.com
19-20 February, 2014	3rd International Conference on Clean and Green Energy - ICCGE 2014 **Place:** Singapore, **Organiser:** International association of chemical, biological, environment engineering scientists(CBEES), **Contact person:** Ms. Sophia Du, +86-28-86528465 E-mail: iccge@cbees.org, **Website:** www.iccge.org
27-28 February, 2014	4th Annual Smart Grids Smart Cities Forum, **Place:** Warsaw, Poland **Organiser:** Fleming Europe, **Contact:** Martin Makara + 421 257 272 143, **Website:** www.energy.flemingeurope.com
4-5 March, 2014	Solar Energy Africa 2014, **Place:** Nairobi, Kenya, **Organiser:** Solar Media, **Contact:** Sue Bradshaw, sbradshaw@solarmedia.co.uk **Website:** www.africa.solarenergyevents.com
5-7 March, 2014	10th Energy Efficiency and Renewable Energy Congress and Exhibition for South-East Europe, **Place:** Sofia, Bulgaria, **Organiser:** Via Expo **Contact person:** Maya Kristeva, +359 (32) 960 011, 966 813 **Website:** www.via-expo.com

RENEWABLE ENERGY AT A GLANCE

Cumulative deployment of various renewable energy systems/ devices in the country as on 31.12.2013

RENEWABLE ENERGY PROGRAMME/ SYSTEMS	TARGET FOR 2013-14	DEPLOYMENT DURING DECEMBER, 2013	TOTAL DEPLOYMENT IN 2013-14	CUMULATIVE ACHIEVEMENT UP TO 31.12.2013
I. POWER FROM RENEWABLES				
A. GRID-INTERACTIVE POWER (CAPACITIES IN MW)				
Wind Power	2500	99.30	1096.50	20149.50
Small Hydro Power	300	31.55	130.90	3763.15
Biomass Power	105	6.00	21.00	1284.60
Bagasse Cogeneration	300	40.40	175.45	2512.88
Waste to Power-Urban-Industrial	20	2.40	3.00	99.08
Solar Power	1100	129.09	495.13	2180.00
Total	4325	308.74	1921.98	29989.21
B. OFF-GRID/CAPTIVE POWER (CAPACITIES IN MW_{EQ})				
Wind Power-Urban Industrial	10.00	2.50	4.06	119.63
Biomass (non-bagasse) Cogeneration	80.00	2.10	38.54	509.69
Biomass Gasifiers-Rural	1.00	0.064	0.35	17.05
-Industrial	9.00	0.250	2.88	141.67
Aero-Genrators/Hybrid systems	1.00	-	0.04	2.15
SPV Systems (>1kW)	40.00	2.52	19.70	144.38
Water mills/micro hydel	500 Nos.	-	-	10.18 (2547 nos)
Bio-gas based energy system	2.00	2.00	-	-
Total	145.00	7.434	67.23	944.75
III. OTHER RENEWABLE ENERGY SYSTEMS				
Family Biogas Plants (No. in lakhs)	1.10	0.40	0.50	47.10
Solar Water Heating-Coll. Areas (Million m^2)	0.60	0.10	0.47	7.47

Volume 7 ■ Issue 4 ■ February 2014

सत्यमेव जयते

inistry of New and
enewable Energy
Government of India

Gift
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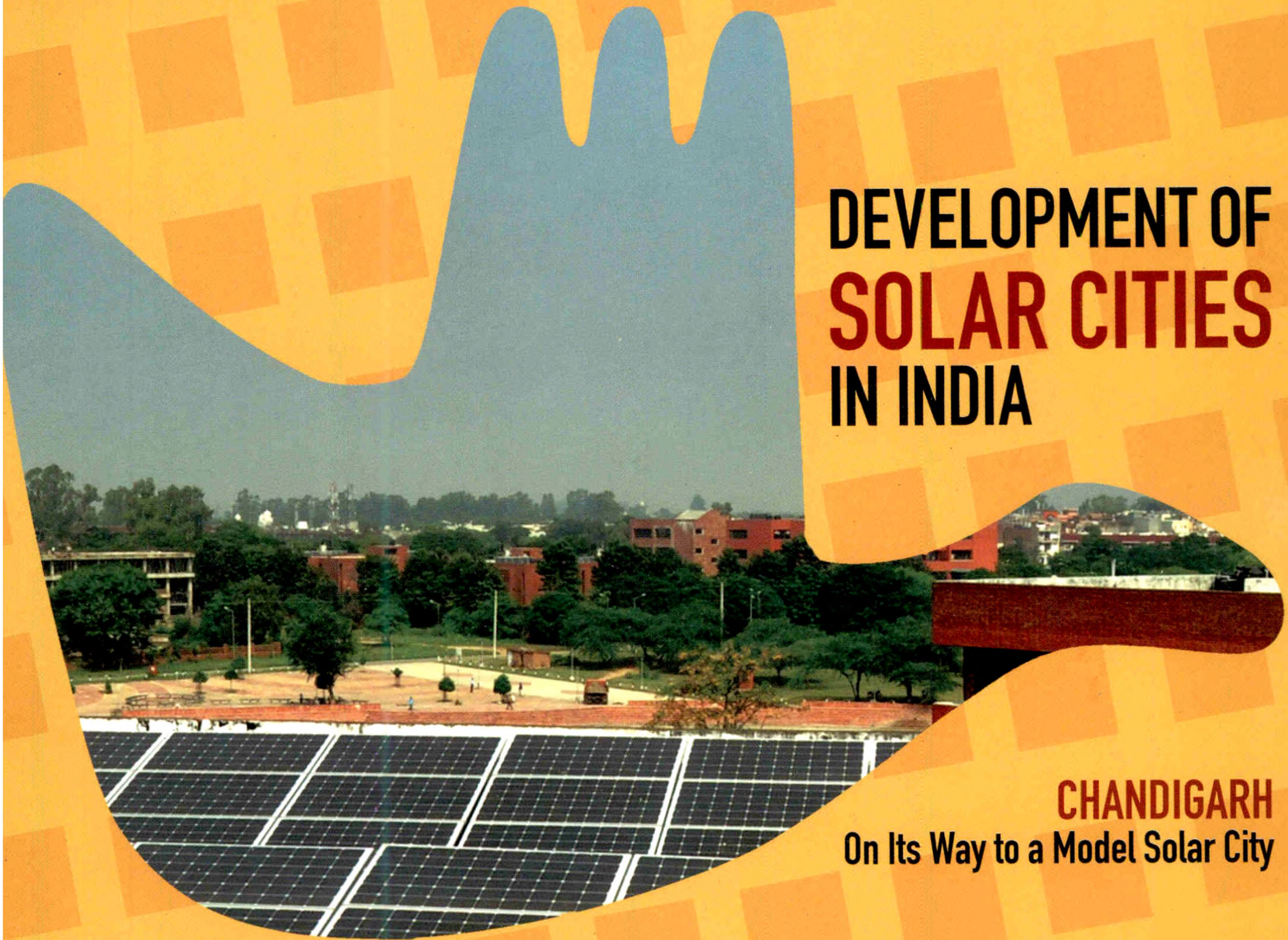
Renewable Energy
Akshay Urja

www.mnre.gov.in

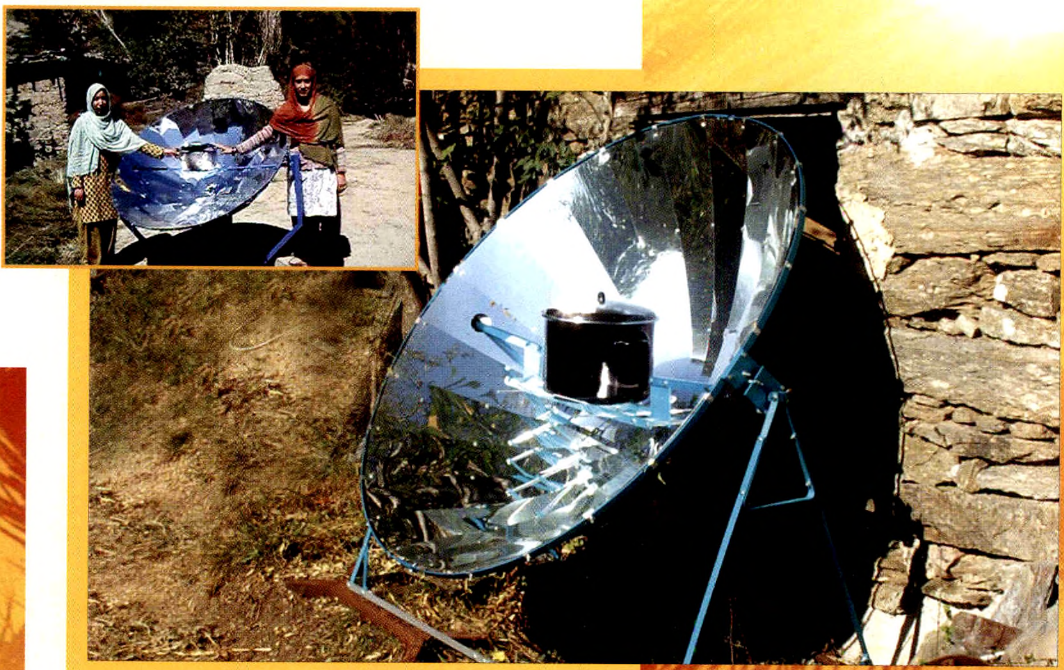


DEVELOPMENT OF SOLAR CITIES IN INDIA

CHANDIGARH
On Its Way to a Model Solar City

Suraj Ek Roop Anek

Dish Solar Cooker



डिश सौर कुकर

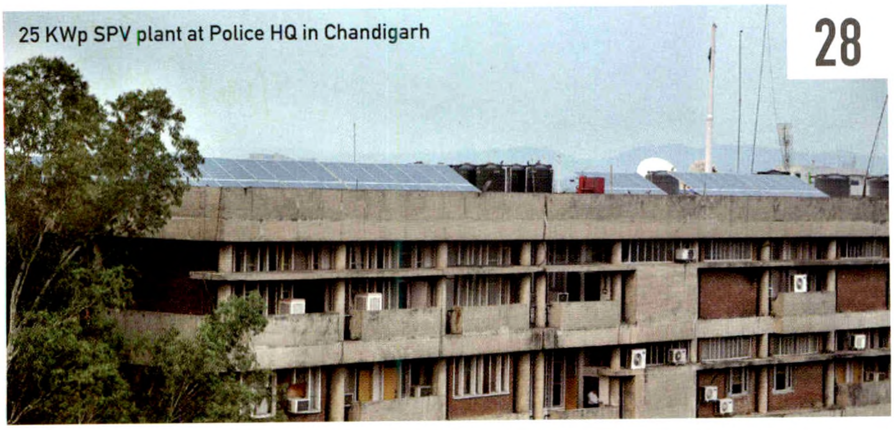
डिश सौर कुकर में आपाती सौर विकिरण के संकेन्द्रण के लिए पैराबोलिक डिश का प्रयोग किया जाता है। इस सौर कुकर को 'एसके–14' प्रकार का कुकर भी कहते हैं। सौर कुकर का यह मॉडल घरों तथा छोटे प्रतिष्ठानों के लिए उपयोगी है। एक प्रकारात्मक डिश सौर कुकर में 1.4 मी. का द्वारक व्यास होता है और इसकी फोकल लंबाई लगभग 0.28 मी. होती है। अन्य आकार एवं बनावट के कुकर भी उपलब्ध हैं।

Dish Solar Cooker

A dish solar cooker uses a parabolic dish to concentrate the incident solar radiation. This solar cooker is also known as 'SK-14' type of cooker. This model of solar cooker is useful for homes and small establishments. A typical dish solar cooker has an aperture diameter of 1.4m and a focal length of about 0.28 m. Other sizes and shapes are also available.

नवीन और नवीकरणीय ऊर्जा मंत्रालय **Ministry of New and Renewable Energy**

FEBRUARY 2014 | Volume 7 • Issue 4 |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- India, UAE to cooperate for renewable energy
- Nagaland successfully tests a dream water solution
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- Crompton Greaves Ltd (CG) launches smart grid manufacturing facility in Bangalore

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- EU urged to set 2030 renewable energy target
- Japan Eyes Smart Meters, Fuel Cells to Tackle Climate Change
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DST, UT Chandigarh has established a "Solar City Cell" in CREST and has developed capacity building through interactions.

HRG took up the pilot project to develop solar passive retrofitting for space heating and solar water heater for houses.

PSH is only a virtual value used to quantify the total energy received from the sun at a specific irradiation value.

Renewable Energy
Akshay Urja

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(Published in English and Hindi)

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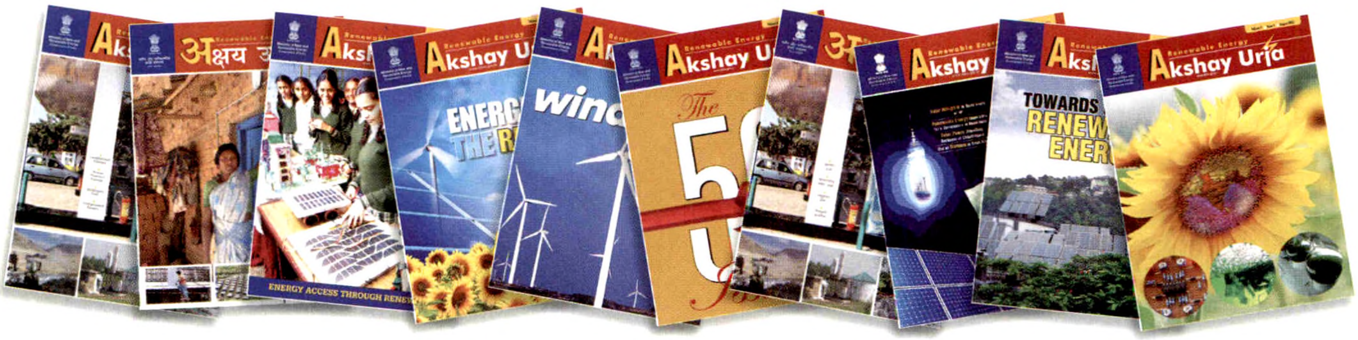


We, at Indian Oil Corporation Limited, are working on Renewable Energy and Sustainable Development. Working in this sector is challenging and requires continuous updation of knowledge and skills.

In view of providing knowledge source at our department, we are in process of developing a small library and consider that the *Akshay Urja* magazine would definitely add to the value of our employees. *Akshay Urja* magazine has been considered as very relevant and informative to our work.

In this regard, I would be grateful if you can kindly send us a printed copy of *Akshay Urja* magazine on a regular basis to aid our efforts.

Shantanu Mukherjee
Assistant Manager
(Sustainable Development)
Indian Oil Corporation Limited

We enjoyed reading the article on biomass co-firing in the *Akshay Urja* magazine (June 2013, p. 70–73). We, at VTT, are currently working on a project on co-firing coal and biomass.

In this regard, could you please provide us the contact details of the author. Also, please let us know the procedure and guidelines in case we wish to publish an article in the future.

Renu Kumar Rathnam, PhD
Research Scientist
CFB Process Development Team
Bioenergy Knowledge Centre
VTT Technical Research Centre of Finland

हमारी संस्था को 'अक्षय ऊर्जा' पत्रिका का 50वाँ अंक प्राप्त हुआ, इसके लिए आपका कोटि-कोटि धन्यवाद। आप इस पत्रिका के माध्यम से विद्युत ऊर्जा की कमी को दूर करने के लिए सौर ऊर्जा के विषय में जानकारी देकर बहुत बड़ा मार्ग-दर्शन कर रहे हैं। ऊर्जा के क्षेत्र में कल का भविष्य 'सौर ऊर्जा' का है।

सौर ऊर्जा को आगे ले जाने में संपादकीय लेख बहुत सटीक है। पवन ऊर्जा के संदर्भ में महत्वपूर्ण जानकारी प्राप्त कर बहुत अच्छा लगा। जन समूह का ध्यान सौर ऊर्जा की तरफ केन्द्रित हो रहा है और पत्रिका जन-जन की बन गई है। इस हेतु बहुत-बहुत बधाई।

अध्यक्ष
अरविन्द महिला विकास क्लब
मढ़ई चौक, बदायूँ, उत्तर प्रदेश

अक्षय ऊर्जा का अंक कभी-कभी पढ़ने को मिलता है। इस बार जून 2013 का अंक कुछ दिन पहले ही मिला, यह वाकई सराहनीय प्रयास है।

मानव जाति को नवीकरणीय संसाधानों के बारे में अधिक से अधिक जानकारी देना व उनके प्रयोग हेतु प्रोत्साहित करना एक उत्तम प्रयास है। हमें यह पत्रिका इस पते पर निरंतर भेजने की कृपा करें। धन्यवाद।

राकेश नरुला
अध्यक्ष, भटिंडा विकास मंच
पावर हाउस रोड, भटिंडा

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of *Akshay Urja* will make every effort to make this newsletter highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in content and presentation.

Editor, *Akshay Urja*

From the Editor's Desk

Dear Readers,

BP Energy Outlook projects that by 2035 global energy consumption will increase by 41 per cent with virtually all (95 per cent) the growth in non-OECD countries and more than half of it coming from India and China. India's energy consumption will grow by 132 per cent while energy production will rise by 112 per cent. Coal will remain the dominant fuel produced in India with a 66 per cent market share in 2035. Renewables in the power sector will overtake oil as the second largest source of fuel, increasing from 3 per cent to 10 per cent in 2035 as oil as fuel will decline from 12 per cent to 4 per cent. Renewables (including biofuels) will account for 7 per cent of total demand in 2035, as compared to present demand of just 2 per cent. By 2035, 14 per cent of world electricity will be from renewable sources, up from just 5 per cent in 2012. CO_2 emissions from energy demand will increase by 117 per cent.

This calls for an increase in energy consumption with larger share of renewables, both worldwide and in India. In the present scenario, several Indian cities and towns are experiencing 15 per cent growth in the peak electricity demand. The local governments and the electricity utilities are finding it difficult to cope with this rapid rise in demand and as a result most of the cities/towns are facing severe electricity shortages. There is a need to develop a framework that will encourage and assist cities in assessing their present energy consumption status, setting clear targets, and preparing action plans for generating energy though renewable energy sources and conserving energy utilized in conducting urban services.

'Solar City' is a concept that aims at about 10 per cent reduction in projected demand of conventional energy in a five year period through a combination of enhanced supply of energy from renewable energy sources and energy efficiency measures. In a solar city, all the renewable energy projects and schemes are integrated to saturate the renewable energy and energy efficiency utilization. Several developed countries, namely, USA, Germany, Australia, and Japan, have promoted this concept, and cities such as Tokyo, New York, and Fraunhofer have taken initiatives to develop solar cities. India has also taken major initiatives to develop 60 solar cities. This will address the energy consumption pattern, assess the utilization of renewable energy resources, and take energy efficiency measures in these 60 solar cities.

Solar City development has been widely covered in the present issue in your hand with a special article on Chandigarh Solar City. Chandigarh has now joined the "energy producers' club". I hope that you will find this issue useful, informative, and interesting. Please do send material on renewable energy for publication along with your suggestions to enrich the content of future issues of *Akshay Urja*.

With best wishes, here's an appeal to adopt the use of renewable energy for your daily energy needs.

A Tripathi

ARUN K TRIPATHI
aktripathi@nic.in

अक्षय ऊर्जा से देश विकास

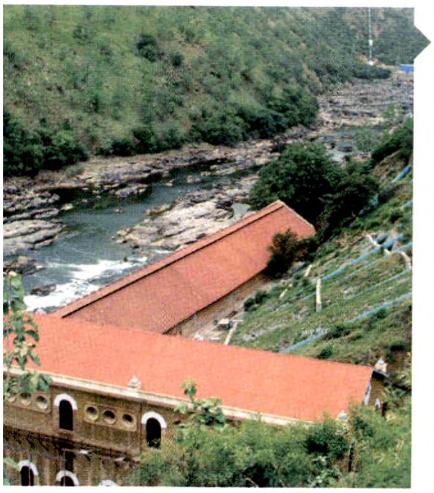
RENEWABLE ENERGY NEWS

CANADIAN BUSINESS HOUSES INTERESTED IN SETTING UP UNITS IN HARYANA

Several business establishments of Canada have evinced an interest in setting up units in agriculture, agri-food, food-processing, education, and renewable energy sectors in Haryana. This was announced at a meeting between Haryana Chief Minister Bhupinder Singh Hooda and a 30-member delegation of Indo-Canada Chamber of Commerce (ICCC), led by its President Nawal Bajaj, in Chandigarh on January 13. Bajaj told Hooda that Haryana has a huge potential in sectors such as education, agriculture, food-processing, and renewable energy, and economic cooperation with the state can go a long way in strengthening the business community in Canada. Responding to the proposal of mutual cooperation in the field of renewable energy, Hooda said Haryana has huge potential in the areas of solar energy as well as energy from solid waste. The State is looking for entrepreneurs to set up their ventures for this purpose. Besides, the state has a huge network of canals which could be used for harvesting renewable energy, the CM told the delegation, according to an official release.

On tapping the energy from solid waste, Hooda said the state government had already prepared a solid waste management policy for Gurgaon and Faridabad under which 1,000 tonnes of solid waste was collected every day. He also referred to the education sector as one of the key areas offering great scope for mutual cooperation.

Source: www.business-standard.com

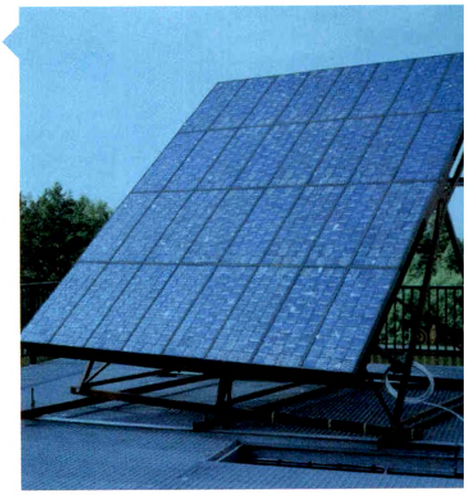


GOVERNMENT TO PUSH DISCOMS TO PURCHASE HYDROPOWER

The government, which plans to make it mandatory for electricity distribution companies to buy hydropower, is also considering launching tradable certificates for the states that do not have potential to meet the proposed obligation. It will kick off the consultation process shortly to amend the Electricity Act to promote investments in hydropower. Hydro energy certificates will enable northern and northeastern states to attract more investments, besides ensuring viability for the projects. "India can tap higher hydropower potential by making it mandatory for distribution companies to promote the same on the lines of solar and wind power. For the states that have geographical limitations to put up hydropower projects, we are considering creating a tradable instrument such as Renewable Energy Certificates (RECs) to meet the hydropower purchase obligation," said a power ministry official. The Ministry has already circulated a concept note among the stakeholders. Based on their feedback, it will propose the quantum of hydropower distribution companies need to procure. It will also establish the value of hydropower certificates. Central Electricity Regulatory Commission introduced REC mechanism to ease the purchase of renewable energy for obligated entities that are not well-endowed with renewable energy sources. One REC represents a megawatt-hour of energy generated from renewable sources.

Source: www.economictimes.com

SCHOOL IN KARNATAKA AIMS FOR ENERGY SELF-SUSTAINABILITY



At a school in Karnataka, power cuts often disrupt studies. And the lack of electricity access means that many students return home to unlit houses. But for the Kalkeri Sangeet Vidyalaya's passion towards sustainability, including the establishment of environment-friendly buildings and an ongoing project to increase the use of solar lighting, it has been shortlisted among the finalists for the Zayed Future Energy Prize.

"The goal of the project is to make the school entirely self-sustainable in terms of energy. We hope to replace incandescent bulbs in classrooms with energy-efficient Light Emitting Diode (LED) lights and Compact Fluorescent Lamps (CFL). At the same time, we hope to use solar energy for hostels, computers, projectors, water heaters, and water pumps. This will create fewer disruptions (for evening classes)," Barbara Schmid, social welfare manager at the school, said.

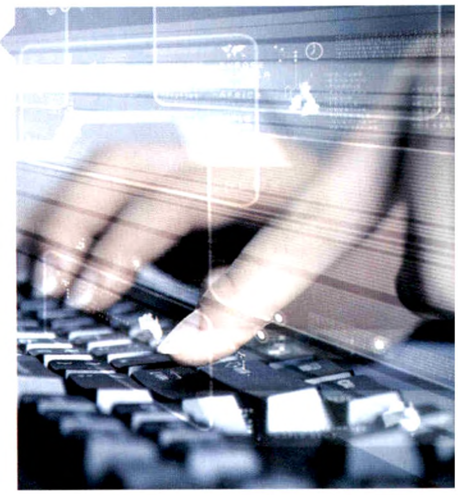
"Moreover, any funds saved from energy use will be used to provide solar home lighting systems for meritorious students whose homes are not electrified," she added.

"In our institution, sustainability is seen as a way of life, not just a school project. All the school buildings are built sustainably, using locally-available materials such as bamboo, mud, and cow dung. Garbage is sorted and recycled, reused or composted by students," Schmid explained.

Meanwhile, a focus on using natural resources encourages the school to use ashes to wash dishes, and to filter soapy water so that it can be used for irrigation.

Source: www.gulfnews.com

JAPANESE FIRMS INTERESTED IN PARTNERING INDIAN COMPANIES TO DEVELOP TECHNOLOGY SOLUTIONS



A renewable energy delegation from Japan is visiting India to explore opportunities for partnership with Indian companies in the renewable energy sector.

Smart grids, waste to energy, and storage solutions clearly emerged as areas where both Japan and India could explore partnerships at the 'Japan India Public Private Round Table on Renewable Energy' organized by the Confederation of Indian Industry (CII) in partnership with the Ministry of New and Renewable Energy (MNRE) under the aegis of Japan–India Energy Dialogue in New Delhi.

Delivering the inaugural address at the roundtable, Dr Satish B Agnihotri, Secretary, Ministry of New and Renewable Energy, said "Storage solutions are amongst the key renewable energy technologies that need to be evaluated. Within storage solutions, it is important to look at hybridization, given the intermittent nature of solar and wind power. Hybridization increases the combined capacity utilization factor thereby improving the financial viability. India also needs to leverage the Japanese experience in smart grid deployment and efficient appliances."

Stressing on the importance of technology, HE Mr Takeshi Yagi, Ambassador of Japan, said "Expansion of technology innovation is extremely important in the renewable energy field. With both Japan and India witnessing a sharp increase in energy imports, renewable energy is a key component of the energy mix. There is a need to harness the huge potential of renewable energy through the development of new technologies and their application to society. It is also important to utilize the private sector's know-how in the areas of waste to energy, storage batteries, and smart grids."

Source: www.business-standard.com

INDIA, UAE TO CO-OPERATE FOR RENEWABLE ENERGY

India's Minister of New and Renewable Energy, Dr Farooq Abdullah, and Sultan, Ahmed Al Jaber, Minister of State and the UAE's special envoy for energy and climate change, on January 18 signed a Memorandum of Understanding (MoU) for cooperation in these areas in Abu Dhabi.

Both the countries also agreed to form a Joint Working Group for better coordination through joint research on subjects of mutual interest, exchange and training of scientific and technical personnel, exchange of available scientific and technological information and data, according to a statement released by the Ministry of New and Renewable Energy. India and UAE have also agreed to cooperate in organization of workshops, seminars, and working groups, transfer of know-how, technology and equipment, on non-commercial basis.

Source: www.post.jagran.com

NAGALAND SUCCESSFULLY TESTS A DREAM WATER SOLUTION

In what has been seen as a path-breaking and revolutionary technology for solving drinking water supply problems in rural areas, the Public Health Engineering Department (PHED) of Nagaland has successfully implemented a new technology using solar energy developed by the Mumbai-based company, Aditya Corporation.

The Solar-Powered Water Treatment Unit, which uses an advanced membrane filtration system, is currently being implemented in the three of the most water scarce villages of Kohima district — Meriema, Tsiesema, and Kijumetouma — under the National Rural Drinking Water Programme, Ministry of Drinking Water and Sanitation, Government of India.

The system, powered by solar energy, is capable of filtering 1,200 litres per hour and can pump water to a height of 200 metres (approximately 650 ft), and is fully automatic in its operation with no necessity of human intervention for day-to-day operation of the system. This system with ultra-filtration gives out treated water that is of high quality for drinking, being free from all physical, chemical, and biological contamination.

Since the need for human intervention is totally done away with in this new technology, it is seen as a very suitable system for rural people as it does not require regular and intensive supervision.

PHED chief engineer Kevisekho Kruse along with SE (M&I) Er Repang Longkumer, concerned EE, SDO, and other staff visited the project sites and interacted with the beneficiaries at the main reservoir site of Meriema on January 10.

Source: www.nagalandpost.com

INDIAN RENEWABLE ENERGY FEDERATION LAUNCHED

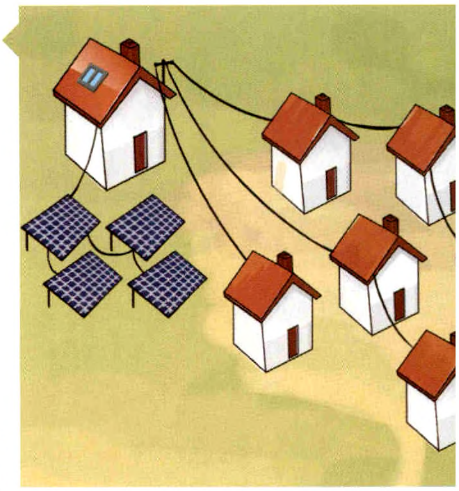
The Indian Renewable Energy Federation (IREF) was formally launched by Union Minister, MNRE, Dr Farooq Abdullah on January 28. IREF is registered as a not-for-profit society under the Societies Registration Act, 1860. It will have a three-tier governance structure: a General Body (GB), a Governing Council (GC), and a Secretariat headed by the Secretary General and a few full-time employees. The vision of the Federation is to function as the apex policy advocacy body for the promotion of renewable energy, energy efficiency, and energy conservation to propel India as a global leader in clean energy technology innovation, production, deployment, service delivery, and market creation. Overall, the mission of IREF is to ensure energy security in India through a planned transition to a clean and sustainable energy economy.

The broad objectives of the federation include carrying out policy advocacy for accelerated development of renewable energy and adoption of energy efficiency, studying the policy and regulatory environment for renewable energy at the centre and state levels, and facilitating regulatory interventions.

The federation is guided and mentored by V Subramanian, Former Secretary, MNRE in collaboration with G M Pillai, Founder Director-General, World Institute of Sustainable Energy (WISE), Pune; Balawant Joshi, Managing Director, Idam Infrastructure Advisory Pvt Ltd.; and Srinivas Krishnaswamy, CEO, Vasudha Foundation. The initiative is supported by Shakti Sustainable Energy Foundation.

Source: http://iref.net.in/

CROMPTON GREAVES LTD (CG) LAUNCHES SMART GRID MANUFACTURING FACILITY IN BANGALORE

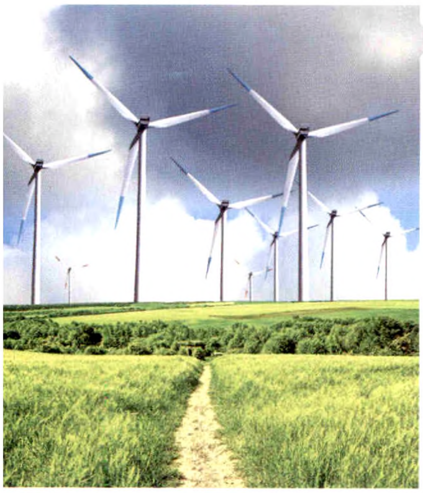


CG, an Avantha Group company based in the Global Village in Bangalore, will produce range of smart grid equipment, including substation automation products, distribution automation devices, and protection and control systems, among other parts. According to Laurent Demortifier, CEO and Managing Director of CG, the smart grid devices manufactured in this facility will offer numerical solutions to Indian utilities and industries in the Transmission and Distribution (T&D) segment and provide improvement in the electric grid to make it more efficient and reliable.

CG has invested Rs 80 million in this facility, which will employ more than 100 people. In addition to producing primary smart grid components, the facility will also offer services such as systems integration, installation, and commissioning. The facility is fully equipped with modern equipment to ensure an annual production capacity of 10,000 units of power line carrier communication terminals and intelligent electronic devices.

CG's smart grid devices are running successfully in the world's first major Smart Grid deployment at the Iberdrola STAR Project, Bilbao, Spain, where more than 227,000 smart meters monitor the electricity services.

Source: www.renewableenergyfocus.com

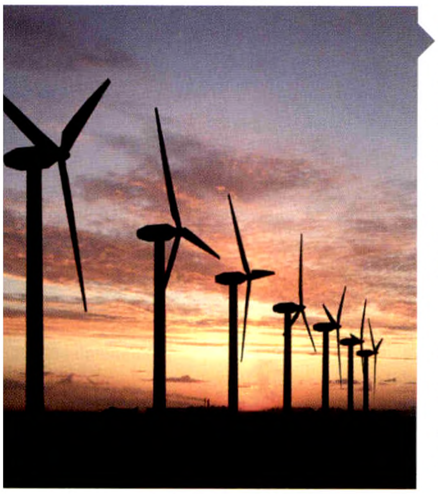


WORLD ENERGY CENTER HEEDS CALL FOR RENEWABLE ENERGY

The Southern California-based World Energy Center is reporting that it has heeded and exceeded President Obama and Vice President Joe Biden's call for the use of renewable electricity. The administration has called, as part of its "new energy plan" for America, to develop and use 25 per cent renewable electricity by 2025. This will spur clean energy jobs, says the Obama administration, as well as reduce greenhouse gases and other sources that lead to climate change.

The World Energy Center consists of more than 30 companies, cities, colleges, participant partners, and affiliates. Larry Hales with Hales Global Group has been providing consultant business development services and says that the World Energy Center is the nation's leading clean energy nerve centre. The centre collaborates with multiple companies to develop the most technological advanced renewable energy projects with the goal of spurring clean energy innovation and creating a commercialization hub to reduce the cost of clean energy and accelerate its worldwide deployment.

Source: www.domesticfuel.com



EU URGED TO SET 2030 RENEWABLE ENERGY TARGET

Ministers from Germany, France, and six other countries have called for the European Union to set a 2030 goal for renewable energy use, in opposition to their British counterpart who advocates a sole greenhouse gas emissions target.

A 2030 renewables goal, which would be part of a package of EU measures on energy and climate change, would cut dependency on fossil fuel imports and boost jobs and economic growth, the group of ministers said.

"A target for renewable energy is crucial to provide certainty that can ensure cost-effective investments in energy systems that will strengthen the internal market for energy," the group of energy and environment ministers said in a letter to Connie Hedegaard, the EU commissioner for climate action, and Guenther Oettinger, commissioner for energy. The letter was signed by ministers from Austria, Belgium, Denmark, France, Germany, Ireland, Italy, and Portugal.

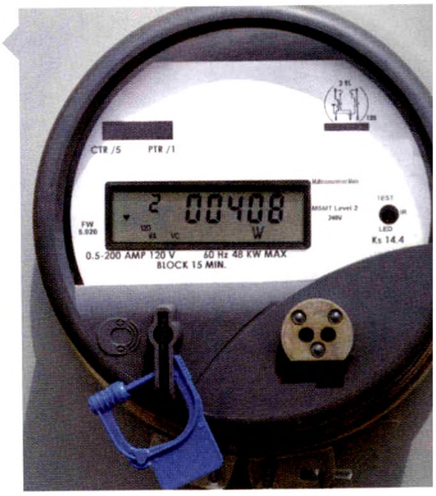
A renewables goal would provide a secure market for manufacturers of wind turbines and solar panels such as Acciona and Vestas. Ed Davey, Britain's energy and climate change secretary, as well as some industry associations have said that they favour a single binding 2030 goal to cut greenhouse gas emissions and head off climate change.

They contend that a single target could be cheaper, giving governments more flexibility in how they choose to cut those emissions, including building nuclear power plants or ramping up energy efficiency measures.

They also fear that a renewables goal will dent the effectiveness of the Emissions Trading Scheme, Europe's flagship climate policy, which has floundered under the current system of three separate 2020 green energy goals — for renewables, efficiency savings, and emissions.

Source: www.theguardian.com

JAPAN EYES SMART METERS, FUEL CELLS TO TACKLE CLIMATE CHANGE



Japan plans smart meters in every residence and factory by the early 2020s and 5.3 million fuel cells in homes by 2030 to tackle climate change, according to a report to be submitted to the United Nations.

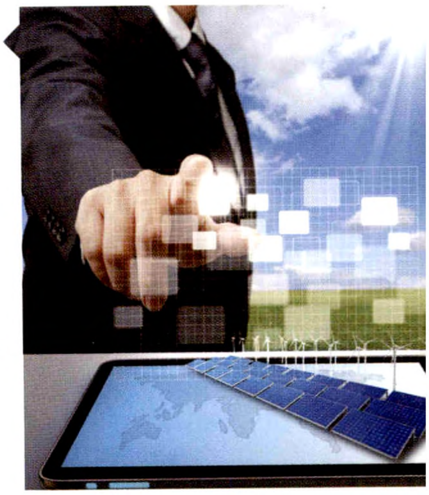
The country will also promote renewable energy as much as possible over the next three years, the Japanese government said in the biennial report, which developed countries were asked to submit by January 1. Nuclear reactors will be restarted after safety is confirmed and thermal power generation efficiency will be enhanced, the government said.

The submission follows Japan's setting of a new, however, target for cuts in greenhouse gas emissions in November 2013. The goal was, however, criticized by environmental groups as being weaker than the previous plan.

The country is debating its energy policies following the 2011 Fukushima nuclear accident. The Ministry of Economy, Trade, and Industry submitted a draft of a new set of policies earlier this month and is seeking comments from the public. Panasonic Corp. and Chofu Seisakusho Co. make residential fuel cells. The devices use the chemical energy of hydrogen to cleanly and efficiently produce electricity with water and heat as byproducts, the US Department of Energy said on its website. Fuel cells release no greenhouse gases and air pollutants at the point of operation.

www.renewableenergyworld.com

RENEWABLE ENERGY OFFERS POTENTIAL FOR JOB CREATION



As businesses around the world realize that sustainable practices are vital to remaining competitive, the Green Career Fair was held in partnership with the Masdar Institute of Science and Technology and Reed Exhibitions during the 7th World Future Energy Summit (WFES) from January 20–22. It is a valuable opportunity for recruiters to highlight job opportunities at their companies and provide career guidance in the advanced energy and sustainability industry.

The Green Career Fair aims to provide cost-effective and convenient ways to create social and professional networking opportunities. Besides meeting up with potential employers, professionals are able to attend workshops on renewable energy career topics and make use of a Career Advice Desk to get tips from HR professionals on site. The fair also includes features such as career opportunity booths and interview areas.

Dr Behjat Al Yousuf, Dean of Students, Masdar Institute, said "Platforms such as the Green Career Fair offer emerging clean energy professionals the right channel for their professional development through engaging with industries in the field to discuss future trends in clean energy capacity building. Mandated to focus on human capital building and knowledge development, Masdar Institute contributes to nurturing a talent base that generates IPs and patents most suitable to the industry. We hope WFES 2014 will serve as the right forum for leading clean energy corporate brands to identify and select the right professional skills to ensure industry growth."

www.saudigazette.com.sa

DEVELOPMENT OF SOLAR CITIES IN INDIA

A Solar City aims at minimum 10 per cent reduction in projected demand for conventional energy at the end of five years, which can be achieved through a combination of energy efficiency measures and an enhanced supply from renewable energy in the city.

ARUN K TRIPATHI

BACKGROUND

Over 30 per cent of the Indian population resides in urban areas. While the population of India has grown three times post-independence, the urban population has grown six times. Urban areas are heavily dependent on fossil fuels (often imported) for the maintenance of essential public services, for powering homes, transport systems, infrastructure, industry, and commerce. Fossil fuels are increasingly becoming more

'Solar City' is a concept to integrate all the renewable energy projects and schemes in a city to saturate the renewable energy applications in various sectors expensive due to scarcity of fuel and increase in demand. In addition to this, the environmental and social impacts of the consumption of fossil fuels are increasingly becoming a concern. These impacts include air pollution, global warming, waste disposal problems, land degradation, and the depletion of natural resources.

Urbanization and economic development are leading to a rapid rise in energy demand in urban areas. Urban areas have emerged as one of the biggest sources of greenhouse gas (GHG) emissions, with buildings alone contributing to around 40 per cent of the total GHG emissions. As per the latest UN report, one million people are moving to urban areas every week. It is estimated that around two-thirds of the world population will be living in cities by 2050. This requires a tremendous shift in energy resources in urban areas. In recognition of this, various cities around the world are setting targets and introducing polices for promoting renewable energy and reducing GHG emissions. London has announced a 20 per cent reduction in carbon emission by 2010; New York and 200 other US cities have set a similar target. Tokyo has announced 20 per cent share of renewables in total energy consumption by 2020 and the Australian government has initiated a Solar Cities programme.

Several Indian cities and towns are experiencing 15 per cent growth in peak electricity demand. The local governments and the electricity utilities are finding it difficult to cope with this rapid rise in demand and as a result most of the cities/towns are facing severe electricity shortages. There is a need to develop a framework that will encourage and assist cities in assessing their present energy consumption status, setting clear targets and preparing action plans for generating energy through renewable energy sources and conserving energy utilized in conducting urban services.

> A SOLAR CITY AIMS TO CONSOLIDATE ALL THE EFFORTS OF THE MINISTRY IN THE URBAN SECTOR AND ADDRESS THE ENERGY PROBLEMS OF URBAN AREAS IN A HOLISTIC MANNER.

'Solar City' is a concept to integrate all the renewable energy projects and schemes in a city to saturate the renewable energy applications in various sectors. To achieve this, the Ministry of New and Renewable Energy has been implementing a "Development of Solar Cities Programme" since 2009 in which 60 cities/towns are being supported for development as "Solar/Green Cities".

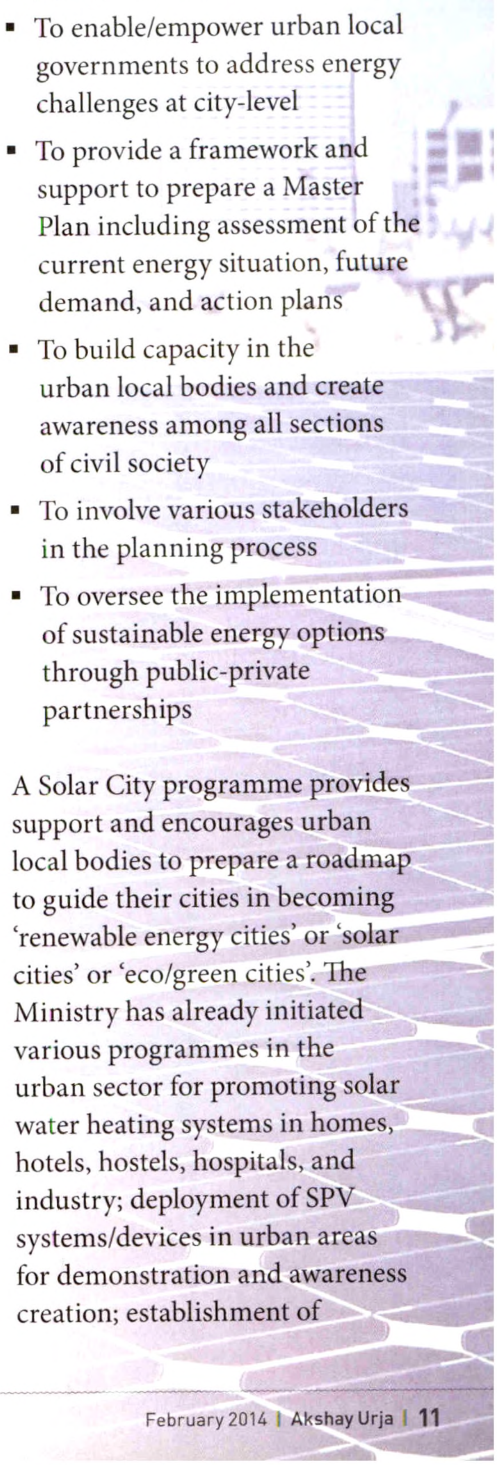
GOALS AND OBJECTIVES

The goal of the programme is to promote the use of renewable energy in urban areas by providing support to the urban local bodies including Municipal Corporations and Municipalities for preparation and implementation of a roadmap to develop their cities as Solar Cities. A Solar City aims at minimum 10 per cent reduction in projected demand for conventional energy at the end of five years, which can be achieved through a combination of energy efficiency measures and an enhanced supply from renewable energy sources in the city.

The specific objectives of the solar city programme are:

- To enable/empower urban local governments to address energy challenges at city-level
- To provide a framework and support to prepare a Master Plan including assessment of the current energy situation, future demand, and action plans
- To build capacity in the urban local bodies and create awareness among all sections of civil society
- To involve various stakeholders in the planning process
- To oversee the implementation of sustainable energy options through public-private partnerships

A Solar City programme provides support and encourages urban local bodies to prepare a roadmap to guide their cities in becoming 'renewable energy cities' or 'solar cities' or 'eco/green cities'. The Ministry has already initiated various programmes in the urban sector for promoting solar water heating systems in homes, hotels, hostels, hospitals, and industry; deployment of SPV systems/devices in urban areas for demonstration and awareness creation; establishment of



'Akshay Urja Shops'; design of energy efficient solar/green buildings; and promoting urban and industrial waste/biomass to energy projects. A Solar City aims to consolidate all the efforts of the Ministry in the urban sector and address the problem of energy in the urban areas in a holistic manner.

SELECTION/IDENTIFICATION OF A SOLAR CITY

The cities which have adopted renewable energy applications and energy efficiency measures with a high level of commitment and leadership qualities are identified. The following points are considered while selecting a solar city:

- City population, regional setting, and prominence in the region
- Political and administrative commitment towards adoption of sustainable energies (resolution to be passed by the City Council/administration for implementing all the activities specified in the Solar Cities Programme)
- Regulatory measures taken for adoption of energy conservation and renewable energy
- Potential for adoption of energy conservation and renewable energy in the city activities
- Initiatives already taken by City Council/administration/ private developers/industry/ general public in promoting energy conservation and renewable energy
- Urban local bodies' previous experience in involving public participation and working with all stakeholders
- Willingness and commitment to providing resources, financial share, and sustenance of activities initiated under the programme

At least one city in each state, and a maximum of seven cities from the interested states are selected on merit. The population of cities/ towns included in the programme should be between 0.50 lakh to 50 lakh including the floating population. Cities with even less population located in North Eastern and hilly states, islands, and Union Territories are considered on merit.

MAJOR ACTIVITIES IN A SOLAR CITY

Solar City Master Plan

The first step after the selection of a city is to prepare a Master Plan within one year as per the guidelines. The Master Plan should provide total and sector-wise projections for energy demand and supply for next the 10 years against a sector-wise base-line on energy utilization and GHG emissions in the city. Year-wise targets for energy conservation, renewable energy addition, and GHG abatement along with an action plan for implementation are clearly brought out in the Master Plan. Potential sources of funding from organizations (both public and private) for providing financial support are identified. The draft Master Plan is discussed in a Stakeholders Consultation Workshop having representation from elected representatives, local research and academic institutions, resident welfare associations, industries and corporate organizations, NGOs, and SNAs. The Master Plan should ensure reduction in their energy consumption from the existing level and consequent reduction in CO_2 emissions. The Master Plan also contains few implementable detailed project reports.

Solar City Cell

A Solar City Cell is created in the City Council which comprises a Senior Administrator and City Engineers, representative of SNAs for planning and implementation and at least one dedicated technical trained person (at least an engineering graduate) supported by a secretarial person who may be exclusively recruited for day-to-day activities in the field of renewable energy/energy efficiency, etc. The other members of the Solar City Cell are nominated by the Municipal Corporation from their existing Officers/Engineers. The Municipal Corporation/SNA also provides supporting infrastructure office space, and related office expenses.

The development of suitable proposals, organizing awareness and capacity-building activities, motivating people towards use of renewable energy, and providing the updated information about the government policies, programmes, benefits, and preparation of proposals for carbon financing etc., besides supporting the Municipal Corporations are the major responsibilities of a 'Solar City Cell'.

Solar City Stakeholders Committee

A Solar City Stakeholders Committee is constituted to provide advisory

TABLE 1: Central financial assistance for Solar Cities

Sl. No	Component/Activity	Central Financial Assistance
1.	Preparation of Master Plan along with few a detailed project reports	Up to Rs 10.00 lakh
2.	Creation and functioning of Solar City Cell	Up to Rs 10.00 lakh
3.	Promotional activities, trainings, workshops, and study tours	Up to Rs 10.00 lakh
4.	Oversight of implementation, guidance, and supervision for RE projects execution	Up to Rs 10.00 lakh
5.	Model Solar City for renewable energy projects as per applicable CFA	Up to Rs 9.50 crore
6.	Pilot Solar City for renewable energy projects as per applicable CFA	Up to Rs 2.50 crore
7.	Green campus development, (for Master Plan, DPR, action plan for renewable energy installations, awareness generation and trainings, etc.)	Up to Rs 5.00 lakh
8.	Organizing seminars/workshops, trainings, awareness campaigns, preparation of literature/ guidelines, city specific publicity materials, etc.	Up to Rs 4.00 lakh for seminars/ workshops, trainings, awareness campaigns, etc., and for other activities on merit
9.	Installation of renewable energy projects/systems in Solar Cities and Green Campuses	As per CFA/provisions of various schemes of MNRE
10.	Innovative projects on smart grid, post-installation service centres, street lights through renewables with centralized power system from solar, biogas generation, kitchen waste-based plants, etc.	As per requirement on merit
11.	Service charges to State Nodal Agencies/ Implementing Agencies	Up to 2 per cent

support to the ULBs/Municipal Corporations. This Committee has representation from elected representatives in the municipal bodies, local research and academic institutions, resident welfare associations, industries and corporate organizations, NGOs, State Nodal Agencies, and other relevant stakeholders.

Capacity Building

Major activities include organizing training programmes/workshops/ business meets/awareness camps, etc., for various stakeholders such as elected representatives of the municipal bodies, municipal officials, architects/engineers, builders and developers, financial institutions, NGOs, technical institutions, manufactures and suppliers, RWAs, etc., and visits/ study tours within India. A Solar City also organizes publicity and awareness campaigns through print and electronic media in the city.

Renewable Energy Projects

A Solar City needs to install various renewable energy projects, adopt renewable energy, and energy efficiency measures for meeting the daily energy requirement.

TARGETS FOR SOLAR CITIES

A total of 60 cities/towns are targeted for development as 'Solar Cities', which will also include 15 cities as 'Pilot Solar City' and eight cities as 'Model Solar City'.

About 100 small townships/ campuses being developed by the promoters/builders, SEZs/ industrial towns, institutional campuses, etc., for preparation of a Master Plan/DPR including the action plan for renewable energy installations and green campus development are also supported. This is also applicable for the existing campuses/townships.

FINANCIAL SUPPORT

The Central Financial Assistance (CFA) is provided for various activities as given in Table 1.

RENEWABLE ENERGY AND ENERGY CONSERVATION PROJECTS/SYSTEMS/ DEVICES FOR SOLAR CITIES

A Solar City will focus on the limited and popular renewable energy projects/systems/devices such as solar PV systems including building integrated photovoltaic, kitchen waste-based plants, solar water heating systems, solar cooking systems, solar steam generating/drying/air heating systems, solar concentrators for process heat applications, solar air-conditioning, power projects on methane recovery from STPs, biomass gasification-based systems, biogas, and wind.

Energy Conservation Devices/Systems

- LEDs/ CFLs instead of incandescent bulbs
- LED traffic lights
- Electronic chokes and fan regulators
- Sensors for automatic on/off of street lights

- Automatic speed regulating fans/motors
- Plugging of leakages in the water supply system and use of efficient pumps and motors
- Energy-efficient electrical appliances such as fans, refrigerators, air conditioners, coolers, room heaters, and water pumps
- Use of insulating materials and low-energy/energy-efficient building materials, e.g., fly ash bricks, hollow bricks, stabilized mud blocks, etc., in building construction
- Any other energy-efficient/energy conservation device, project being promoted by BEE, Ministry of Power or MNRE

Solar Passive Architecture in Buildings/Housing Complexes

Major components of solar passive architecture include orientation of a building, sun shades, double glazed windows, smart glazing window overhangs, thermal storage wall/roof, roof painting, ventilation, evaporative cooling, day lighting, wind towers, earth air tunneling, construction materials, etc. Incorporation of specific components will depend on the climatic zone the building is being constructed in.

GREEN BUILDINGS

The construction of Green Buildings has been as per the GRIHA Rating, LEED India, ECBC Building Code, BEE Star Rating, ECHO Housing, and other rating systems.

- Measures to be taken by City Council/Administration for developing the Solar City
- To create a "Solar City Cell" within the City Administration/Council, which will be fully responsible for city planning and implementation of projects
- To conduct energy auditing of government/public sector buildings, water pumping, and street lightings in the city at regular intervals and take necessary steps towards conservation of electricity. Other establishments would also be encouraged to follow the same practice
- To reduce electricity consumption in street lights garden lights/traffic lights/blinkers hoardings, etc., by using energy conservation and renewable energy devices
- To amend building by-laws for making the use of solar water heating systems mandatory in certain categories of buildings
- To provide rebate in property tax through Municipal Corporations/Municipalities and in electricity tariff through utilities/electricity boards for the users of solar water heaters especially in the domestic sector
- To issue GO as regards to construction of energy-efficient solar buildings at least in government/public sectors in accordance with ECBC:2006 and follow up the implementation rigorously
- To comply with MSW Rules 2000 notified by the MoEF and set up projects of suitable capacity for generating energy from the waste collected from cities/towns
- To organize rigorous publicity, and also training programmes/business meets for various stakeholders, e.g., architects, engineers, builders and developers, financial institutions, NGOs, technical institutions, manufactures/suppliers, RWAs, etc., so as to involve them actively in meeting the objectives of Solar City
- To generate necessary funds from state government and other funding organizations for achieving the objective of making the city a Solar City. Benefits of the schemes of the Government of India will also be taken into account to meet the objectives

- To achieve targets set by the City Council/Administration for reducing the consumption of electricity through renewable energy and energy conservation devices during the five years of implementation for developing the city as Solar City

IMPLEMENTATION ARRANGEMENTS

State Nodal Agencies/Urban Local Bodies or other corporate houses for respective cities are implementing the solar city projects. For townships and institutional campuses, the respective organizations are implementing the project.

DECLARATION OF A 'SOLAR CITY'

The development of Solar Cities is a long-term process. This starts with the identification of a city, development of a proposal and sanction for development of a Solar City, preparation of a Master Plan, constitution of the Solar City Cell and a Stakeholders Committee, approval of Master Plan, preparation of specific proposals for approval, and installation of renewable energy projects/energy efficiency devices, etc. Initially the sanction is accorded for "Developing a Solar City", and a developing Solar City can be declared a 'Solar City' if substantial amount of activities have taken place in the city with the objective of reducing the fossil fuel-based energy consumption by 10 per cent.

CURRENT STATUS OF SOLAR CITIES

Out of the selected 45 cities the Master Plans have been prepared for 37 cities, namely, Agra, Moradabad, Gandhinagar, Rajkot, Surat, Kalyan-Dombiwali, Thane, Shirdi, Nagpur, Indore, Gwalior, Imphal, Kohima, Dimapur, Chandigarh, Gurgaon, Faridabad, Bilaspur, Raipur, Agartala, Guwahati, Jorhat, Hubli-Dharwad, Mysore, Aizawl, Itanagar, Coimbatore, Shimla, Hamirpur, Jodhpur, Vijayawada, Ludhiana, Amritsar, Chamoli-Gopeswar, New Town Kolkata, Bhubaneswar, and Aurangabad. The remaining eight cities are Ajmer, New Delhi NDMC area, Howrah, Panaji City, Nanded, Dehradun, Haridwar-Rishikesh, and Rewa.

Four cities, namely, Nagpur, Chandigarh, Gandhinagar, and Mysore, are being developed as 'Model Solar Cities', and 10 cities, namely, Agartala, Rajkot, Shimla, Faridabad, Thane, Shirdi, Leh, Aizawl, Puduchherry, and Amritsar are being developed as 'Pilot Solar Cities'.

Renewable energy projects with an aggregate capacity of over 5.0 MWp Solar PV plants, 61 solar hybrid invertors, 342 Solar Street Lighting Systems, and 5.05 lakh lpd Solar Water Heating Systems have been sanctioned in pilot/model solar cities which are at various stages of implementation.

> SOLAR CITY COVERS THE ENTIRE RENEWABLE ENERGY SECTOR AND ENERGY EFFICIENCY MEASURES. THE SOLAR CITY HAS BEEN SUCCESSFUL IN MOTIVATING URBAN LOCAL BODIES, WHICH ARE NOW ADOPTING RENEWABLE ENERGY AND ENERGY EFFICIENCY IN THEIR MAIN ACTIVITIES

CONCLUSION

The Indian Solar City programme is a very comprehensive programme which aims to develop 60 Solar Cities in the country. The Solar City covers the entire renewable energy sector and energy efficiency measures. The Solar City programme has been successful in motivating the urban local bodies, which are now adopting renewable energy and energy efficiency in their main activities. They are also making/modifying the suitable by-laws for promoting renewable energy in their respective cities. However, many milestones are yet to be reached for developing these 60 Solar Cities in the real sense in the country.

Arun K Tripathi is Director, Ministry of New and Renewable Energy. Email: aktripathi@nic.in

SOLAR HEATING SYSTEM

A BOON FOR POOR RURAL HOUSES IN THE HIMALAYAN REGION

The Himalayan Research Group (HRG) took up the pilot project of developing solar passive retrofitting for space heating and solar water heaters for houses in villages of Mashobra Block of District Shimla.

SARITA BRARA

Moolkoti is a Gram Panchayat village 22 km from Shimla in Mashobra Block in Himachal Pradesh. With low temperatures prevailing almost throughout the year, one needs a constant supply of warm water for daily chores such as washing clothes and utensils, bathing, etc. It also becomes essential to keep the house warm in such cold weather. Due to limited resources and income of poor rural households, most families rely on fuel wood collected by women from nearby forests. This fuel wood is burnt in the traditional open cooking stove called '*Chulah*', which is used for heating water, cooking food, as well as keeping the house warm. In fact in many households in the hilly areas, family members sit in the kitchen for most of the day because it is cold elsewhere in the house. Some even sleep in the kitchen when it becomes unbearably cold. What people are unaware of is the fact that the smoke emanating from these open stoves is harmful for their health. It is an additional burden for women who spend several hours a day collecting fuel wood. Most importantly the high dependence on fuel wood poses a potential threat to the ecology of the region.

Woman filling hot water from community solar water heater

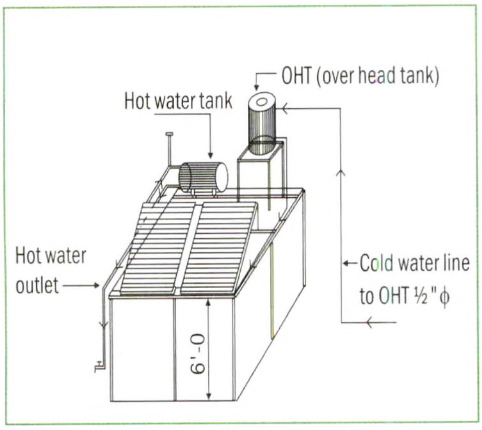
Leelawati, a homemaker in Moolkoti village, was not an exception. She says that she had to walk 3 to 4 km up and down the hill every day to collect fuel wood. But for the last four years, her drudgery has been considerably reduced by almost three-fourth, thanks to the Himalayan Research Group (HRG) that has installed innovative water heating systems meant for rural households. Her son says that his frequency of taking a bath has increased from once a week to every day now.

HRG, a core group under the Department of Science and Technology (DST), took up the pilot project with financial support from it to develop solar passive retrofitting for space heating and solar water heaters for household clusters in villages of Mashobra Block of District Shimla to reduce dependence on fuel wood.

So it is not just individual households such as Leelawati's which have benefitted but these solar water heaters have also been installed for use by the community as a whole. Three solar water heaters of 200 litre capacity each were installed for a cluster of households catering to the requirement of around 9-10 households in each of the villages to provide for the requirement of hot water for washing, bathing, and utensil cleaning.

This concept was mooted to popularize these modern technologies among rural masses keeping in view their individualistic approach and financial constraints despite heavy government subsidy.

> THIS CONCEPT WAS MOOTED TO POPULARIZE THESE MODERN TECHNOLOGIES AMONG RURAL MASSES WHICH THEY MAY NOT SEE AND USE KEEPING IN VIEW THEIR INDIVIDUALISTIC APPROACH AND FINANCIAL CONSTRAINTS DESPITE HEAVY GOVERNMENT SUBSIDY.



Design of solar water heater

Community solar water heater

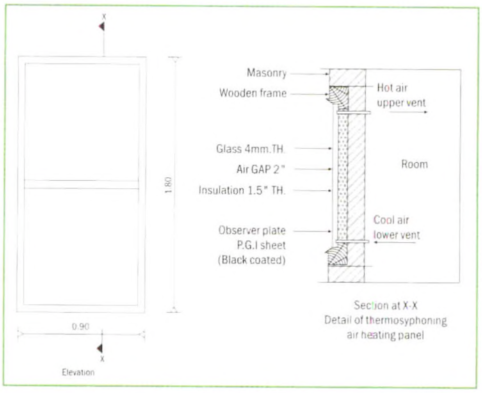
In Shilru, the villagers say that they have been using the community water heater since it was installed without any problem. Hot water is available any time of the day from morning till 10.30 at night, say homemakers with a smile on their faces.

"So much time was spent earlier to get the fuel wood and we used to be so tired. Now we can utilize that time in a better way," says one of the ward members of the village Panchayat.

The community water heater has been installed at a location in the village which is approachable by a number of households. What's more, a street light that runs on solar power, too, has been installed, so that when it is dark in the early morning and late in the evening, women and the children can fill their buckets with warm water without any fear. Under the projects, community water heaters were also installed in Kandi and Moolkoti villages. Care was taken to ensure that the poorest of the lot were able to benefit the most through this pilot project. The hamlets in hilly areas sometimes have just a few houses. Devaku, a widow, lives alone in a house on a hill with no other house in the nearby vicinity. With a tiny land holding it is not enough to even get two square meals a day.

To warm houses the HRG designed solar passive retrofitting locally. Local carpenters were trained and locally available wood, glass, and steel sheets were used. According to Director HRG Dr Lal Singh, this is a modification blended with modern material to tap maximum solar energy for warmth of the houses backed with scientific principles. He says that solar passive retrofitting, namely, Thermosyphoning Air Heating Panel (TAP), Trombe Wall (TW), and Sun Spaces (SS) were designed for existing houses keeping in view their orientation to the sun. Solar retrofitting was installed on the south facing wall of the houses.

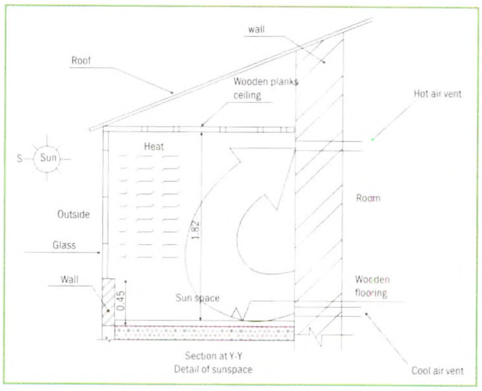
> TO WARM HOUSES, THE HRG DESIGNED SOLAR PASSIVE RETROFITTING LOCALLY. LOCAL CARPENTERS WERE TRAINED AND LOCALLY AVAILABLE WOOD, GLASS, AND STEEL SHEETS WERE USED.



Design of Thermosyphoning Air Heating Panel (TAP)

TAP in a rural house

Sun Spaces were created through glazing of open spaces on south facing sides. Glazing of small portion of this open space on south facing side with 5 mm glass fixed in wooden grooves serves as the air heating unit. Inmates use this space for sittings during daytime, or air heated in this space was also introduced into the adjoining room through doors or vents as described in the case of TAP. Leakage of hot air through glass sides, roof, and between partitions was prevented with silicon and fevicol sealants. To exhaust the hot air during summer, ventilators or windows can be opened.



Design of Sun Space

Sun Space in rural house

Kundan Lal, an ex-serviceman, proudly showed the Air Heating Panel installed in his house. The house remains warm for most of the day and late at night, except on the days when it is raining or snowing, he says. His daughter-in-law says that she is blessed to be married to his son, because unlike other women she does not have to go up and down the hills to collect fire wood and the house is warm most of the time.

The HRG also plans to install eight solar street lights in two of the villages on village paths to provide illumination late in the evening. This not only gives them a sense of security while walking at night (from the wild animals) but also provides security for transportation of agriculture produce.

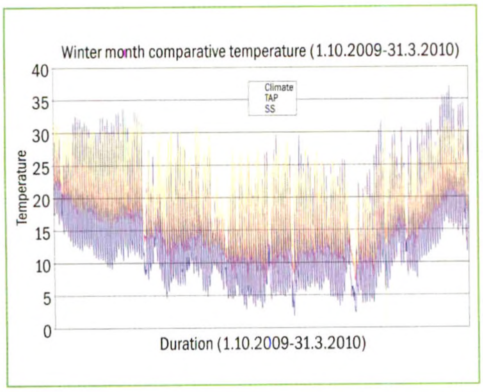
A survey was done by the HRG before the installation of solar devices in rural household in Mashobra Block of District Shimla to assess the energy needs in village Moolkoti, Mashobra, and Shimla.

Table 1. Energy needs in village Moolkoti, Mashobra, and Shimla

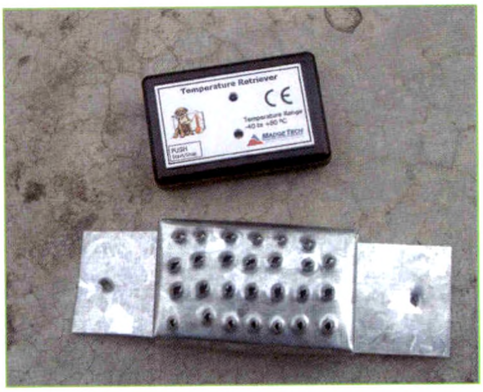
Sl. No.	Detail	Summer	Winter	Cost
1.	Quantity (kg) of fuel wood required/day/household	16.45	39.45	Free of cost
2.	Time (in hrs)/household /visit for collection of fuel wood (240 visits/annum)	1.57	1.59	Opportunity cost is Rs 15.0/hr
3.	Distance (km) covered/visit for collection of fuel wood	1.62	1.57	On foot
4.	LPG cylinder consumed/month	1.09	1.59	Rs 370/- cylinder
5.	Electricity (kwh/month)	23	68	Rs 2.83/kwh (subsidized)

After the survey, 45 Thermosyphoning Air Heating Panels were installed, 34 in Moolkoti village and 11 in Shilru, six Sun Spaces in Moolkoti village and one Trombe Wall type.

To get an idea of thermal efficiency and comfort evaluation of retrofitting, a data logger was installed in the living room of one of the houses fitted with Thermosyphoning Air Heating Panel and another one was installed to monitor the outside temperature for comparison.



Reading recorded in a data logger



A data logger

THE HRG ALSO PLANS TO INSTALL EIGHT SOLAR STREET LIGHTS IN TWO OF THE VILLAGES ON VILLAGE PATHS TO PROVIDE ILLUMINATION LATE IN THE EVENING.

> IT IS ESTIMATED THAT INSTALLATION OF SOLAR RETROFITTING FOR SPACE HEATING AND SOLAR WATER HEATERS WILL REDUCE CONSUMPTION OF FUEL WOOD TO 40 PER CENT.

Temperature profile for thermal performance of two solar passive retrofitting units was recorded for more than one year. For the study, winter season of six months was considered from October to March. The data showed that the temperature tends to fall below 10 °C in the morning hours from mid October and till mid February. TAP and SS provided 8 °C–10 °C increase in temperature of the living space in comparison to the outside temperature. TAP and SS retrofitting were day features to provide thermal comfort during day time and save fuel wood and prevent compulsory sitting in the kitchen.

The HRG also did an analysis of consumption of fuel wood before and after the installation of these devices in the selected villages.

TABLE 2: Consumption of fuel wood and carbon savings

Sl. No	Specifications	Value
1.	Average monthly (winter) per capita consumption of fuelwood in Mashobra Block of Shimla (kg)	236.7
2.	Winter season (six months) per capita consumption (kg)	1420.2
3.	No. of households with Solar Passive Retrofitting and solar water heater	82
4.	Average household population	6
5.	Total average population of 82 households	492
6.	Total consumption of fuelwood of 82 households in winters (tonne)	698.74
7.	Carbon conversion @ 1.46/kg CO_2	1020.16
8.	40 per cent efficiency during six month winter season through Solar Passive Retrofitting = savings (kg)	408063.22
9.	Saving in Carbon Tonnes during six month winter season	408.06
10.	Average household carbon saving in tonnes (six month winter)	4.97

» Devaku's house with solar heating system (Trombe Wall type)

Leelawati's house with solar water heating system

It is estimated that installation of solar retrofitting for space heating and solar water heaters will reduce consumption of fuel wood to 40 per cent and, on an average, there will be a reduction of 4.14 tonnes carbon per household in temperate rural households during the six winter months. This will provide respite to women from collection of fuel wood and reduce drudgery and help in saving natural resources.

The use of clean solar aided devices in space and water heating resulted in reduction of indoor pollution and women's drudgery in collection of fuel wood. The projection related to reduction in carbon emissions and saving of carbon per household is very encouraging, says Dr Lal. He says that the concept of such interventions needs to be further popularized across large sections of households to meet the increasing energy requirement in rural areas and reduce dependence on fuel wood.

The project initiated by the HRG has run successfully for over four years and has stood the test of time. There has not been any major problem so far except a bit of wear and tear that the locals have managed to plug by themselves.

There are a total of 6.66 million rural households in the Himalayan region in India. If these heating systems, with a cost-effective modification to suit the local conditions and availability of local resources, are installed, this will no doubt contribute to conservation of the natural resources, which is a priority for states such as Himachal Pradesh, and the Himalayan Region in particular. This will considerably bring down carbon emissions and reduce the drudgery of women in the Himalayan Region.

This is an effective technology and its implementation will mitigate household emissions. Exhaustive exercises on development, fabrication, and installation of solar retrofitting for existing houses in the Himalayan Region in India is expected to reduce dependence on fuel wood and help in reduction of women's drudgery.

> THE USE OF CLEAN SOLAR AIDED DEVICES IN SPACE AND WATER HEATING HAS RESULTED IN REDUCTION OF INDOOR POLLUTION AND WOMEN'S DRUDGERY IN COLLECTION OF FUEL WOOD.

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A 3 kw solar plant installed at village Navapara, District Raipur

MINI-GRIDS

CHALLENGES AND THE WAY FORWARD

About 1500 villages in Chhattisgarh have been electrified in the last 10 years through 4 to 15 kilowatt solar power mini-grids installed by CREDA.

SHAILENDRA SHUKLA

Memories of a dark life are still fresh in the minds of residents of Rawan, a remote village in Baloda Bazar district of Chhattisgarh. It was not long ago when as darkness descended, villagers would struggle to carry out basic household chores. Children had to bend over books to study in the faint glow of kerosene lamps, whereas women were resigned to the fate of cooking over fires fuelled by animal waste. To fetch drinking water, villagers had to walk three kilometres every day. "Our village never had electricity; we struggled without it," said the Village Sarpanch (chief). "Clearance issues with the forest department made it difficult to bring power to our area, so we were always forced to depend on kerosene lamps to light up our dark homes after sunset."

But all this changed in 2003, when about 350 residents of Rawan moved away from darkness and embraced light. Working in close cooperation with local residents, Chhattisgarh Renewable Energy Development Agency (CREDA), a state nodal agency for renewable energy, built a 7 kilowatt solar energy-based mini-grid to deliver electricity throughout the village. The plant, constructed in just two months, delivers power to all the 70 households. Now, in Rawan, villagers' lives no more come to a standstill at sunset.

About 1500 villages in Chhattisgarh share a similar story, having been electrified in the last 10 years through 4 to 15 kilowatt solar power mini-grids installed by CREDA. This project is solely managed by the local community

सौर ऊर्जा से विद्युतीकृत
कम्प्यूटर प्रशिक्षण केंद्र
छात्रावास विद्यार्थियों के लिये
कम्प्यूटर प्रशिक्षण योजना
अनु.जाति बालक छात्रावास

through a Village Energy Committee. On an average, the solar plant generates 300–1200 units of electricity a month and its performance can be monitored in real time with a proper metering system.

Based on the success of the project, MNRE, along with other state nodal agencies, planned to electrify more remote villages in India.

Apart from India, other countries of Southeast Asia, Africa, and Latin America also replicated the same model to electrify remote villages. We are excited by the prospect of providing villages with a steady source of clean renewable energy that has an impact on their lives.

In the last couple of years, several SNAs and private companies have come forward to electrify far-flung villages by setting up renewable energy (RE) based mini-grids. However, there is very little data in the public domain about the number of such RE-based mini-grids, their installed capacity, and generation details. Also, there is presently no regulatory oversight mechanism in this sector even with regard to consumer tariffs and effectiveness of the use of the government subsidies in cost reductions. A Framework for Policy Design which discusses mini-grid policies of various countries and proposes elements of RE-based mini-grid policy for India is required.

ENERGY SHORTAGE IN INDIA

Over 1.25 billion people in the world have no access to electricity. Of these, nearly 290 million live in India without grid connectivity; this means they resort to burning kerosene in basic wick lanterns to produce light at night and use biomass for cooking. Over 90 per cent of dark households are concentrated in rural India. There is no dearth of programmes and agencies involved in electrifying remote places in India. Various government policies promote development of mini-grids, including RE-based mini-grids. Mini-grids are defined as one or more local generation units supplying electricity to domestic, commercial, or institutional consumers over a local distribution grid.

A girl studying under solar light

A 4 kw solar power plant installed at village Rawan, District Baloda Bazar

Although mini-grids can use diesel generators, RE-based mini-grids use electricity generation technologies that utilize locally available sources such as solar, wind, biomass, and run-of-river hydro. India's first mini-grid was set up in Lamni of Chhattisgarh in 1992. It is still maintained and working satisfactorily.

The Union Ministry of New and Renewable Energy (MNRE) has been providing capital subsidies for off-grid RE mini-grids such as biomass gasifiers, micro hydro and solar PV (photovoltaic) for more than a decade. Two of its famous programmes are the Village Energy Security Programme and the Remote Village Electrification (RVE) programme. The latter was initially set up to support solar home lighting systems and lanterns in remote villages, but now also supports mini-grid development in villages not covered under central grid extension efforts.

Such mini-grids are mainly operated by village electricity committees formed by the local community. For instance, a local villager, trained by CREDA, is in-charge of the day-to-day operation of the solar plant. He is assisted by an electrician from a nearby village. In Chhattisgarh, MNRE's state nodal agency is operating more than 1,500 solar PV mini-grids under the RVE programme, powering more than 75,000 households.

Further, the Jawaharlal Nehru National Solar Mission has an ambitious target of 20,000 megawatts (MW) for grid connected solar PV systems and 2,000 MW of off-grid solar PV systems. Under the mission, the Centre provides capital subsidies for solar plants. The Union Ministry of Power is also promoting isolated mini-grids under the Decentralized Distributed Generation (DDG) scheme of Rajiv Gandhi Grameen Vidyutikaran Yojana. To add to all these government schemes and policies, private developers have also joined the fray to set up mini-grids in remote locations. With so much activity happening in the sector of RE-based mini-grids, it comes as a shock that the Indian government has not put in place any regulatory framework to monitor such projects.

> SOME OF THESE CHALLENGES ARE HIGH UP-FRONT CAPITAL COSTS, LOW CAPACITY FACTORS, HIGHER TARIFF AS COMPARED WITH CENTRAL GRID, INSUFFICIENT FINANCING SUPPORT AND INVESTMENT, TECHNOLOGY FAILURE, LACK OF INSTITUTIONAL ARRANGEMENTS AND GRIEVANCE REDRESSAL MECHANISM.

CHALLENGES GALORE

According to the Electricity Act of 2003, no license is required for generation and distribution of power in notified rural areas. This means that any agency or private developer can set up a grid in these rural areas and start supplying electricity to rural consumers by mutually agreeing upon a tariff.

Private developers face several challenges to successfully deploy mini-grids and ensure their long-term sustainability. Some of these challenges are high up-front capital costs, low capacity factors, higher tariff as compared with central grid, insufficient financing support and investment, technology failure, lack of institutional arrangements, and grievance redressal mechanism. Shortage of adequate government machinery and infrastructure were among the challenges we faced while setting up solar plants in remote villages. During the post-setup phase, regular maintenance of the plant came with challenges of its own considering the lack of skilled manpower in close proximity.

Private developers need to be supported to be able to carry out electrification of difficult areas. However, there is a dire need to regulate this sector. For instance, there is no comprehensive data on the number of RE-based mini-grids in India. There is no information on their total capacity. Reads a 2011 report, Policy and Regulatory Interventions to Support Community Level Off-grid Projects, prepared by ABPS Infrastructure Advisory Pvt. Ltd: The off-grid renewable projects are intended to cover those unelectrified villages which are remote and unlikely to get electrified through extension of grid in near future through various ongoing rural electrification schemes. For large scale deployment, it is necessary to develop robust policy and regulatory intervention.

At present the government's role is mainly limited to provision of capital subsidies and possibly selection of villages for such mini-grids. The consumer tariff is mutually agreed between the developer and the community. The power tariff of mini-grid consumers is always higher than those of the central grid

> AT PRESENT THE GOVERNMENT'S ROLE IS MAINLY LIMITED TO PROVISION OF CAPITAL SUBSIDIES AND POSSIBLY SELECTION OF VILLAGES FOR SUCH MINI-GRIDS. THE CONSUMER TARIFF IS MUTUALLY AGREED BETWEEN THE DEVELOPER AND THE COMMUNITY.

« Solar street light

Solar power plant installed at Barnavapara Abhiyaranya

because of various reasons such as high transaction costs, low loads, high specific costs of the renewable generating capacity at smaller scale, etc. However, there is a need to have equitable tariffs. This can be done by cross-subsidizing the higher cost of electricity from renewable-based mini-grids by central grid consumers, which would result in an extremely negligible increase in grid consumer's tariffs. Chhattisgarh government is contributing Rs 40 per month per household for maintenance of the solar mini-grid. The recurring cost such as replacement of the batteries is also borne by the state government.

A recent report by Prayass has raised the issue of unregulated tariff of RE mini-grid projects: In places where mini grid tariffs are unregulated ... the results can be quite varied, from tariffs being insufficient to cover generation costs to developers charging relatively high tariffs.

Private developers, however, disagree. Currently, the capital subsidy stands at 30 per cent, which is insufficient for solar power projects, thereby leading the developer to invest on its own and seek external funding to execute the project. Mini-grids are a fairly new segment in India which is still in takeoff mode. Once a business model is tried, tested, and successful, it can be used as a reference to arrive at a viable solution for regulating the tariff.

Children studying under solar lamp

The Forum of Regulators (FoR), set up under the Electricity Act of 2003, is considering a model where the tariffs of mini-grids will be regulated and made equitable with central grid counterparts while the project developer will be provided an ongoing viability gap subsidy to ensure a profit margin. FoR has proposed a new regulatory mechanism Model Draft Regulations for Off-grid RECs for Community Level Off-grid Projects for RE-based mini-grids in India. However, these regulations are only guiding in nature and not mandatory. It is for the State Electricity Regulatory Commissions to adopt and notify them in their respective states.

Meanwhile, some developing countries are already regulating consumer tariffs for mini-grids. For instance, in Brazil, tariffs are set by Brazilian Electricity Regulatory Agency for both grid-connected and off grid consumers, served by concessionaires. The Cambodian electricity framework requires a license for operating a mini-grid and therefore makes the operators subject to tariff regulation. In Tanzania, the law mandates that retail tariffs should be determined by the developer and first presented to the local community for their opinion. The Tanzanian regulatory authority approves it only after the community agrees to the tariff.

There are other challenges as well, such as grid integration. There is no clarity on how standalone mini-grids would be integrated with the central grid once the latter reaches remote locations. There is an urgent need to plan in advance for intentional islanding—a method by which one can switch between the central grid and off-grid.

POSSIBLE WAY FORWARD

According to Prayass, an RE-based mini-grid policy needs to be designed according to clearly defined roles for all stakeholders. Appropriate licensing and regulations can ensure compliance and affordability for consumers but should keep transaction costs low for developers and not compromise project viability. Training and capacity development of all stakeholders including the community, project developers, government officials, regulators, utility personnel, and financiers is essential to develop a strong mini-grid sector. Robust and appropriate monitoring and verification mechanisms should ensure quality of service without being cumbersome to stakeholders.

Private developers are also demanding a strong and regulated policy framework, which would help private developers in scaling the business and creating an efficient outreach into all rural and remote areas facing a lack of electricity. Lack of infrastructure in remote areas is an added hurdle towards project execution. Central machinery at the state-level could help resolve this issue by supporting project execution. The cost for this set up could be borne by the developer at nominal and pre-approved rates, hence, benefitting both entities.

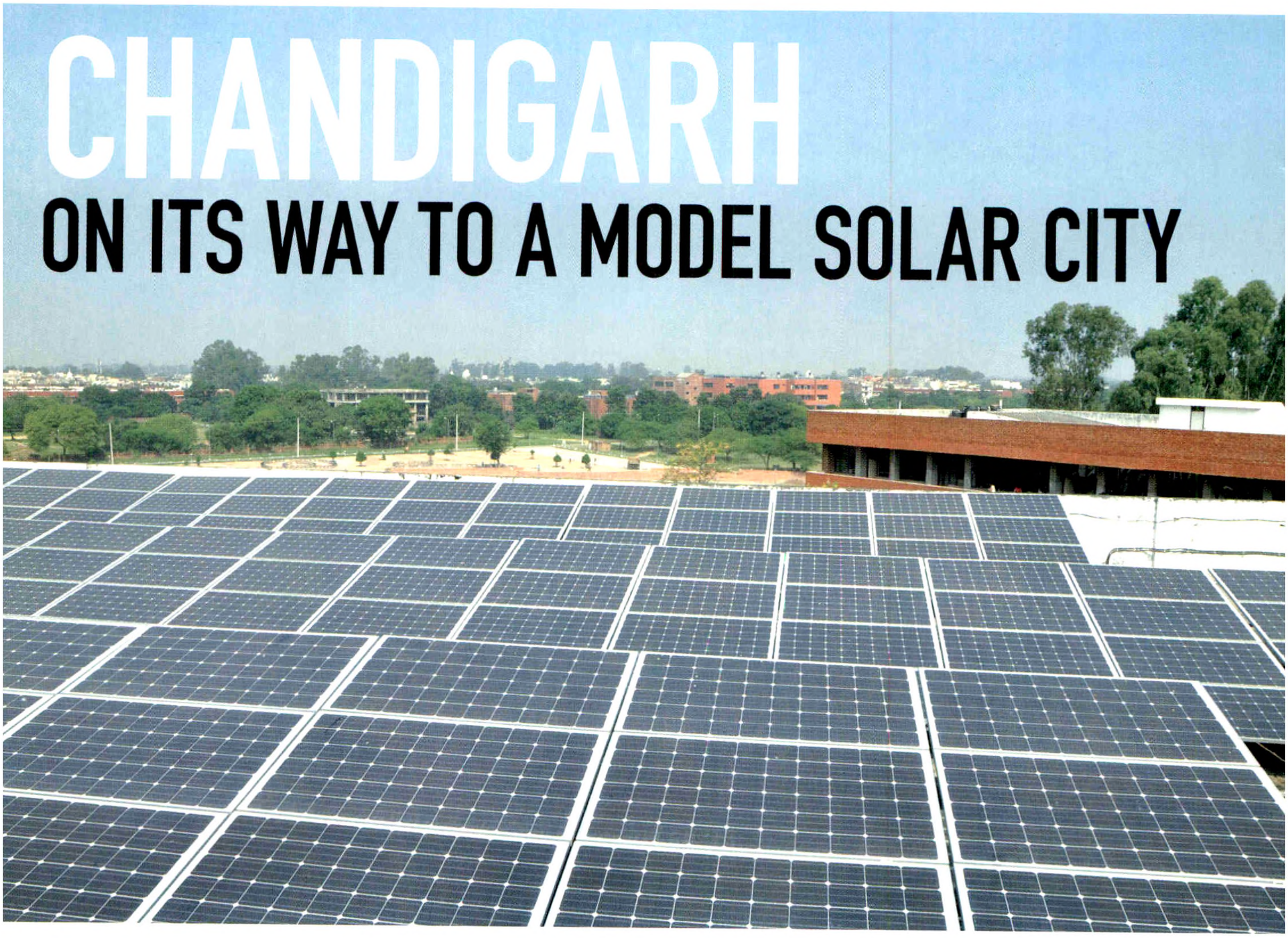
With regards to land issues, the solar projects in rural areas should be given priority in allocation from the gram panchayat, block administration, or district administration. To overcome the challenge of tariff collection, an efficient collection network may also be created. AU

Shailendra Shukla is CEO, CREDA, Chhattisgarh.

A woman stitching for livelihood

CHANDIGARH

ON ITS WAY TO A MODEL SOLAR CITY



200 kWp SPV plant at Government Girls College, Sector-42

The Department of Science and Technology, UT Chandigarh has established a Solar City Cell in CREST and has developed capacity building through interactions, seminars, and field visits to other solar plants in the country.

SANTOSH KUMAR

Under its Solar City Programme, the Ministry of New and Renewable Energy (MNRE) selected Chandigarh for to be developed as a Model Solar City. According to the guidelines, one of the pre-requisites for this was preparation of a Master Plan for Solar City. The Master Plan for Model Solar City was prepared by The Energy and Resources Institute (TERI). On January 4, 2012, the High Power Technical Committee of MNRE approved the Master Plan for Chandigarh.

The project was sponsored by the Chandigarh Renewable Energy Science and Technology Promotional Society (CREST), which is the nodal agency for executing solar and other RE projects.

SOLAR CITY: THE CONCEPT

A "Solar City" is an urban area that aims to:

- Reduce dependence on fossil fuels for its energy needs; and
- Limit emission levels to sustainable levels even while maintaining the desired socio-economic development growth.

The Solar City aims at minimum 10 per cent reduction in projected demand of conventional energy at the end of five years through a combination of enhancing supply from renewable energy sources in the city and energy efficiency measures.

ENERGY CONSUMPTION SCENARIO IN CHANDIGARH

The peak electricity demand of UT Chandigarh is around 350 MW which is being met from different central/state level power utilities and generating stations. The Union Territory has no generation capacity of its own and is receiving power from three entry points. These points are Mohali (Punjab) (67 per cent), Dhulkote (BBMS) (10 per cent), and Nalagarh (23 per cent). The electricity consumption of Chandigarh is increasing by approximately 52 million units every year. The energy consumption scenario is depicted in Table 1.

Out of 350 MW, 37 per cent is being used by the domestic sector, 29 per cent by the commercial sector, 25 per cent by the industrial sector, 8 per cent by agriculture, and 1 per cent by others.

As per guidelines issued by MNRE, Government of India, 3 per cent of total energy consumption is to be obtained from renewable energy sources under RPO (Renewable Purchase Obligation) for UT Chandigarh, and out of this 0.40 per cent is to be from solar energy. Thus, about 5.4 million units are to be produced/obtained from solar energy. In order to meet its RPO obligation, UT Chandigarh has conceived Rooftop-based SPV Power Projects as use of other renewable sources such as wind power and hydel power is minimal in the Union Territory.

> IN ORDER TO MEET ITS RPO OBLIGATION, UT CHANDIGARH HAS CONCEIVED ROOFTOP-BASED SPV POWER PROJECTS AS USE OF OTHER RENEWABLE SOURCES SUCH AS WIND POWER AND HYDEL POWER IS MINIMAL IN THE UNION TERRITORY.

TABLE 1: Energy consumption scenario

Year	Electricity Consumption (Million Units)
2008-09	1143.31
2009-10	1237.58
2010-11	1284.45
2011-12	1348.89
2012-13	1500.20

Solar energy initiatives/strategies being adopted in Chandigarh:

- Rooftop-based Solar Photovoltaic Power Generation (Grid Interactive)
- Solar Water Heating System
- Streetlight system in parks, gardens, etc.

ROOFTOP-BASED SPV POWER PLANTS PROJECT

As per the Master Plan, the short-term target (3 years, 2014) for Rooftop Solar PV system is 2.5 MW, and the long-term target is 10 MW (10 years, 2022).

As per the Master Plan of Model Solar City, the following targets are proposed (see Table 2 on the next page). These targets are based on the detailed energy audits in Chandigarh and renewable resource potential assessment.

TABLE 2: Targets in order to develop Chandigarh as Model Solar City

Sl. No.	Description	Targets		
		Short Term (till 2014)	Medium Term (till 2017)	Long Term (till 2022)
1.	**Energy Conservation**	**Reduction in present energy consumption**		
	Residential sector	10%	15%	20%
1.2	**Commercial sector**	**10%**	**15%**	**20%**
1.3a	Municipal sector (Water pumping)	5%	8%	12%
1.3b	**Municipal sector (Street lighting)**	**10%**	**20%**	**25%**
2.	Coverage of solar water heating systems (as a proportion of total heating demand in residential and commercial sectors)	10%	25%	45%
3.	**Rooftop solar energy-based electricity generation**	**2.5 MW**	**5.0 MW**	**10.0MW**
4.	Large solar energy-based electricity generation at landfill site	3.0 MW	5.0 MW	5.0 MW
5.	**Large solar energy-based electricity generation at Patiyala ki Rao site**	**5.0 MW**	**15.0MW**	**25.0MW**
6.	GHG emission reduction (tCO_2/annum)	90,973	214,051	404,969

PROGRESS SO FAR

The Department of Science and Technology, UT Chandigarh, has established a Solar City Cell in CREST and has developed capacity-building through interactions/seminars/field visits to other solar plants in the country. CREST is preparing a Detailed Project Report (DPR) for Grid Interactive Power Plant in-house and is sending it to MNRE for sanction.

As of today, around 5 MWp Rooftop SPV Plants have been sanctioned by MNRE in the last two years. Eight SPV Plants of overall capacity 550 KWp are already commissioned. Another four plants of overall 1300 KWp are under installation at four different colleges and likely to be commissioned within one month. A 1 MWp Rooftop SPV plant at Punjab Engineering College, Sector-12 has been sanctioned and work order has been issued, which is likely to be completed by May 2014. Sanction for 2.8 MWp has been received from MNRE in January 2014. There is a plan to install Rooftop SPV Plants on 32 different government schools of Chandigarh in 2014.

Besides this, CREST has installed five Rooftop SPV Plants on government residential houses. It has also advertised a new scheme recently, in which an individual private householder can convert an existing normal inverter to solar inverter by installing solar panels and charge controller, thereby, start using solar energy. MNRE is providing subsidy of 30 per cent of project cost on it.

Chandigarh as Model Solar City was formally launched by Hon'ble Minister, Dr Farooq Abdullah, MNRE on July 3, 2013 with the inauguration of two Rooftop

> AS OF TODAY, AROUND 5 MWp ROOFTOP SPV PLANTS HAVE BEEN SANCTIONED BY MNRE IN THE LAST TWO YEARS. EIGHT SPV PLANTS OF OVERALL CAPACITY 550 KWP ARE ALREADY COMMISSIONED. ANOTHER FOUR PLANTS OF OVERALL 1300 KWP ARE UNDER INSTALLATION AT FOUR DIFFERENT COLLEGES AND LIKELY TO BE COMMISSIONED WITHIN ONE MONTH.

« 25 KWp SPV plant at Police HQ in Chandigarh

Grid Interactive SPV Plants at Paryavaran Bhawan, Sector-19 (50 KWp) and at Model Jail, Burrail (100 KWp).

Following are the innovations in procurement/installation of SPV Power Plants in Chandigarh:

- **Minimum Electricity Generation**: While finalizing Detailed Notice Inviting Tender (DNIT), it was felt that in order to ensure quality, it is necessary to put a clause of Minimum Electricity Generation in the DNIT and accordingly, based on the latitude and solar radiation available in Chandigarh, NIT stipulates that every 100 kWp Solar SPV system has to generate 130,000 units (KWh) of electricity per year.
- **Minimum Efficiency of Solar Panel Prescribed**: A minimum efficiency of the solar panel to be used has been prescribed (15 per cent). Only 'Made in India' solar panels are used.
- **Grid Interactive SPV System**: All the Solar PV Power Plants established in Chandigarh have been made grid interactive, so that the solar power generated in excess of local building demand is exported to the grid.
- **Third-Party Inspection**: A provision has been made for third party inspection for all the Solar PV projects to ensure quality and monitoring of SPV systems being installed.
- **Bi-Directional Meter**: A provision of a bi-directional meter has been kept in all the SPV projects so as to keep the accounting of solar energy that is exported to the grid so as to meet Renewable Purchase Obligation (RPO), and to earn revenue by selling this solar power generated to the Discom.
- **10 Year O&M**: There is a provision of 10 years operation and maintenance (O&M) of the plant in the DNIT which will ensure that good quality materials are supplied by the bidder as they have to operate and maintain the plant for 10 years as well as having to meet the Minimum Electricity Generation Target each year.
- **Insurance**: In the DNIT, a provision for insurance of the entire project has been made so as to meet unforeseen circumstances such as damage to the solar plant due to fire, winds, etc.

TABLE 3: Latest Status of Solar Projects already sanctioned by MNRE, GoI in UT Chandigarh as on December 30, 2013

Sl. No.	Project Name	Capacity (KWp)	Executing Agency	Remarks
1.	Paryavaran Bhawan, Sec-19	50	M/s Sova Power Ltd. Kolkata	Project completed and commissioned
2.	Govt Model Sr. Sec.School, Sec-46	50	M/s DD Solar 23, Gurgaon	Project completed and commissioned
3.	Model Central Burrail Jail, Sec-45	100	M/s DD Solar 23, Gurgaon	Project completed and commissioned
4.	Estate Office (D C Office), Sector-17	75	M/s C & S Electric Pvt Ltd, Gurgaon	Project completed and commissioned
5.	Police Headquarters, Sector-9	25		
6.	Govt. Medical College and Hospital, Sector- 32	100		
7.	Govt. Multi Specialty Hospital, Sector-16	70		
8.	Govt. College of and Commerce and Business Administration, Sector-42	50		
9.	Post Graduate College, Sector-46	210	M/s C & S Electric Pvt Ltd, Gurgaon	Project completed. However, evacuation of power on HT side (11 KVA) is to be done. Likely to be completed by 30 Jan, 2014
10.	Govt. College for Girls, Sector-42	200		
11.	Govt. College for Men, Sec-11	435	M/s Punj Lloyd Delta Renewable Pvt. Ltd., Gurgaon	Project completed. However, evacuation of power on HT side (11 KVA) is to be done. Likely to be completed by 15 Feb, 2014
12.	Govt College for Girls, Sec-11	495	M/s Punj Lloyd Delta Renewable Pvt. Ltd, Gurgaon	Project completed. However, evacuation of power on HT side (11 KVA) is to be done. Likely to be completed by 30 Jan, 2014
	Grand Total	1,860		

210 KWp SPV plant at Post Graduate Government College, Sector-46

TABLE 4 : Projects under execution

Sl. No.	Project Name	Capacity (KWp)	Status of Projects
1.	IRB Complex, Sarangpur	200	Under execution, likely to be completed by Feb 2014
2.	Punjab Engg. College, Sec-12	1,000	Under execution, likely to be completed by 31 May, 2014

SOLAR WATER HEATING SYSTEMS

Chandigarh is providing one of the highest subsidies for the installation of Solar Water Heating Systems.

About 30 per cent capital subsidy is also being provided by MNRE, Government of India, for installation of Solar Water Heating Systems for domestic, industrial, and commercial sectors.

In addition, 25 per cent of system cost is also being provided to the beneficiary by the Department of Science and Technology, Chandigarh as financial assistance.

SOLAR STREET LIGHTING SYSTEM

Municipal Corporation of Chandigarh is installing solar lights in places such as parks and gardens. Following are the places where solar lights are being installed:

- Botanical Garden
- Bougainvillea Garden
- Rajendra Park
- Rock Garden
- Shivalik Garden
- Rose Garden
- Shanti Kunj
- Leisure Valley, and others

Santosh Kumar, IFS, is Director (Science and Technology) and CEO, CREST.
crestchandigarh@gmail.com

70 KWp SPV plant at Government Multispeciality Hospital, Sector-16

SIX PSUS SIGN UP FOR WORLD'S LARGEST SOLAR PLANT

Three ministries of the Government of India — Ministry of New and Renewable Energy, Ministry of Heavy Industries, and Public Enterprises, and Ministry of Power — have joined hands to launch a 4,000-MW ultra-mega solar power project at Sambhar in Rajasthan, expected to be the world's largest. Six PSUs under these ministries, including Bharat Heavy Electricals Ltd (BHEL), PowerGrid Corporation of India, Sambhar Salt Ltd, Rajasthan Electronics and Instrumentation Ltd, Solar Energy Corporation of India, and SJVN Ltd have signed an MoU to develop and operate this project.

The joint venture company will have an equity participation of 26 per cent from BHEL (Bharat Heavy Electricals Ltd), 23 per cent from SECI (Solar Energy Corporation of India), 16 per cent from SSL (Sambhar Salt Ltd), 16 per cent from Power Grid, 16 per cent from SJVNL (Satluj Jal Vidyut Nigam), and 3 per cent from REIL (Rajasthan Electronics and Instruments Ltd).

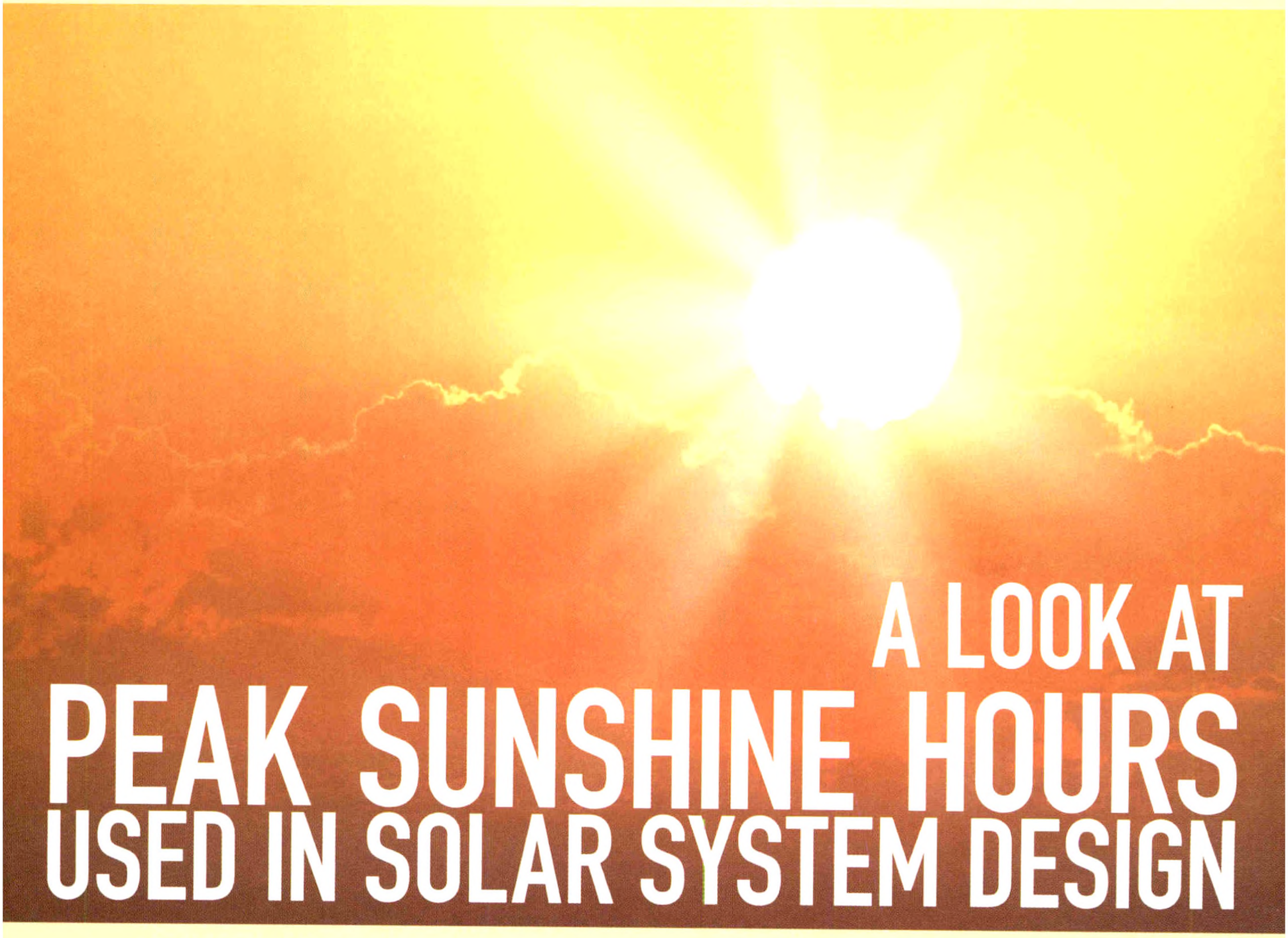
The Chairman-cum-Managing Directors (CMDs) of these six PSUs were joint signatories to the agreement signed in New Delhi. The MoU was signed in the presence of Praful Patel, Union Minister for Heavy Industries and Public Enterprises and Dr Farooq Abdullah, Union Minister for New and Renewable Energy. The project will come up on 19,000 acre of surplus land available with SSL in Sambhar, Rajasthan. The equipment will be supplied by BHEL, power evacuation by Power Grid, sale of electricity by SECI, operation and maintenance by REIL and project management by SJVNL.

The project will be developed in different phases in 7 to 8 years. The first phase of 1,000 MW is planned to be set up in about three years. The other 3,000 MW will be set up in subsequent phases.

The department of heavy industry would set up a special purpose vehicle for executing this project, which will require an investment of Rs 7,500 crore in the first phase.

The Solar PV (photo-voltaic) power plant will use PV modules based on crystalline silicon technology. With an estimated life of 25 years, the 4,000 MW of the solar plant is expected to supply 6,400 million units of energy per year and consequently help to reduce carbon dioxide emissions by over 4 million tonnes per year, said a government release.

Source: http://indianexpress.com/article/business



A LOOK AT PEAK SUNSHINE HOURS USED IN SOLAR SYSTEM DESIGN

PSH is only a virtual value used to quantify the total energy received from the sun at a specific irradiation value.

NIKHIL P G

The remarkable progress in the contribution of renewable energy in the Indian power sector portfolio during the last three decades is proof of the enormous scope and opportunities in clean energy technologies, especially in solar energy. Thus, knowledge of the continuously varying solar irradiation data is very important for the optimal design and sizing of any solar energy-fuelled system. The unavailability of solar irradiation data specific to a particular location has been a major challenge for the design engineers; however, a recent initiative by the Centre for Wind Energy Technology (C-WET) to set up solar irradiation assessment units across the country will address these challenges. In spite of all these efforts, most of the industry players still adopt/use an average value (mostly known as Peak Sunshine Hours) of the solar irradiation for the design which make the calculations simple and concise. This article, throws light on the concept of Peak Sunshine Hours (PSH) employed in the design of a solar system. The comparative variation in the system performance while employing PSH value over the hourly solar irradiation value is also investigated. An example of a standalone photovoltaic system is considered to demonstrate the concept. An analytical model is also presented which will be useful for any solar application designer for deriving the hourly solar irradiation values for a given day of any location from the PSH value.

WHAT IS 'PEAK SUNSHINE HOURS'?

Peak Sunshine Hours (PSH) is an indicative value which is equivalent to the number of hours representing the total solar energy received on a given day corresponding to an irradiation of 1000 W/m^2. Technically, PSH is a conceptual value signifying the hours during which a PV generator would have operated at its rated conditions during a day. A schematic representation of PSH is given in Figure 1. It may be noted that the area under the two curves is the same. Hence, practically, PSH value represents duration of total available energy content from the source, at a standard irradiation value. The value of PSH can be derived from the Global Average Solar Radiation (GASR) value, as given in the equation, PSH = GASR/1000, where GASR is measured in Wh/m^2/day. For example, if the measured global solar irradiation for a given location is 300 W/m^2 for the first two hours, 700 W/m^2 for the next four hours, and 400 W/m^2 for the last three hours, then the total GASR will be 4600 Wh/m^2 (300x2 + 700x4 + 400x3). Hence the PSH of the given location would be 4.6 hours for the given day.

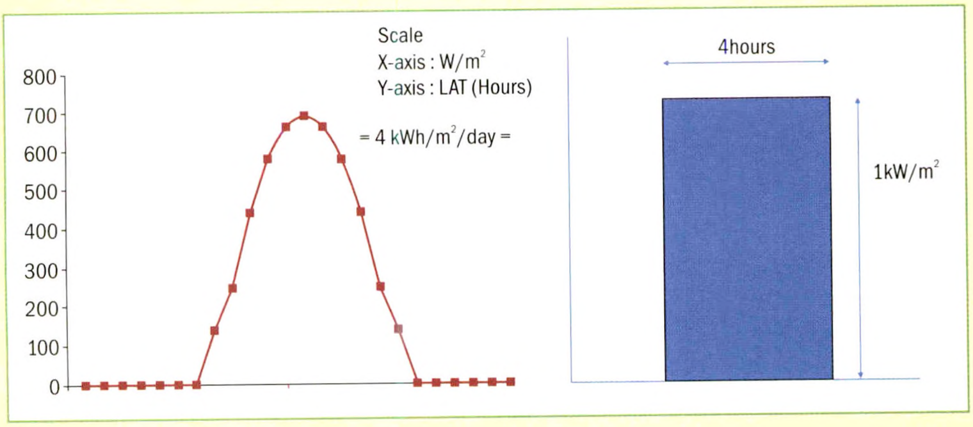


Figure 1: Schematic representation of Peak Sunshine Hours

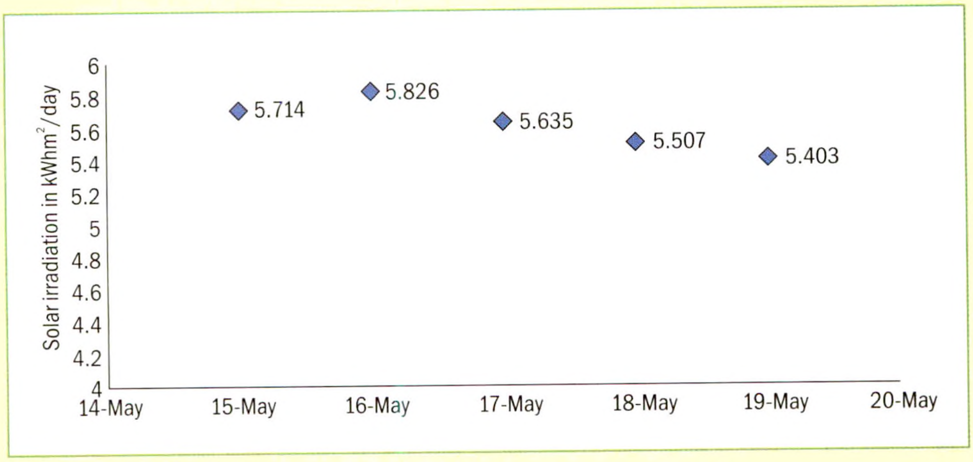


Figure 2: Values of Peak Sunshine Hours for five days in the month of May 2013 in Vellore, Tamil Nadu

> BEING A SINGLE VALUE REPRESENTING THE SOLAR IRRADIATION INPUT, PSH HAS BEEN A FAVOURITE OF MANY DESIGNERS, AND IN THE MAJORITY OF THE CASES EITHER GASR$_y$ OR THE LOWEST VALUE OF GASR$_m$ FOR THE YEAR IS USED FOR THE DESIGN.

It may also be noted that the GASR value is different for each day of the year, as is the Peak Sunshine Hours. For instance, Figure 2 (on the previous page) is an example of PSH (GASR) for five different days in the month of May 2013 for Vellore district of Tamil Nadu. Also, the daily irradiation values of a month can be averaged to obtain a Monthly Average Global Solar Irradiation ($GASR_m$), and the daily irradiation values for a complete year can be averaged to obtain a Yearly Average Global Solar Irradiation ($GASR_y$). The $GASR_m$ and $GASR_y$ for Vellore are shown in Figure 3.

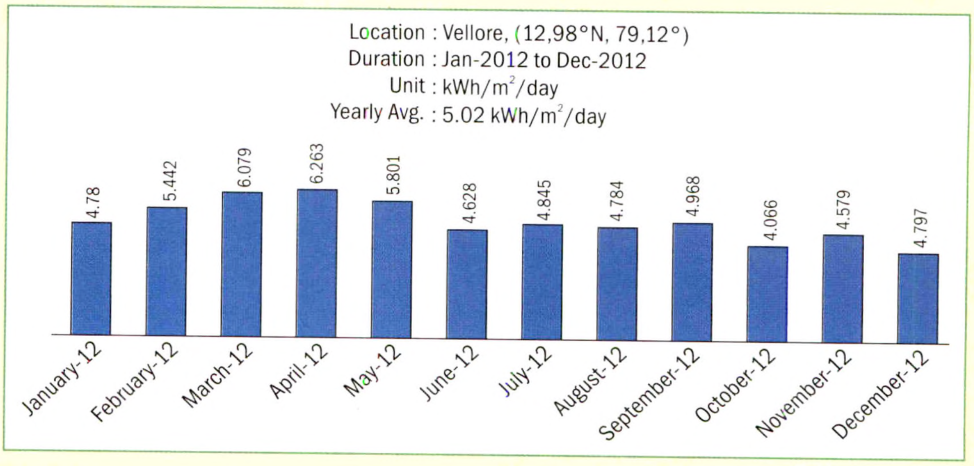


Figure 3: Variation in $GASR_m$ over a year for Vellore district of Tamil Nadu

Being a single value representing the solar irradiation input, PSH has been a favourite of many designers, and the majority of the cases either $GASR_y$, or the lowest value of $GASR_m$ for the year is used for the design. Will this approximation of irradiation input affect the performance of the system? If, yes to what extent? Will it undersize or oversize the system? Let us have a look.

INFLUENCE OF PSH ON SYSTEM SIZING

To understand the influence of PSH on system performance, compared over hourly irradiation value, an example of a load of 1000 W consuming 12 units/day (between 6 am and 6 pm) is considered. The required energy is met by a standalone PV system. The irradiation input is 4 kWh/m²/day. The normal profile represents the response when hourly value of solar irradiation is employed, and the rectangular profile represents the simulation carried out using PSH value. The values of PV power output along with battery voltage, and battery state of charge is simulated for the similar conditions for two different solar irradiation inputs. The simulated results shown in Figure 4 (on the next page) are for only five days.

It is observed that when PSH value is used, the system performance is underestimated, causing over-sizing of the system requirements. This is because while considering the PSH value for design the energy source is assumed to occur only during some hours of the day at which considerable charging takes place. During other times, the input is assumed to be zero, and hence the battery voltage steeps down. Moreover, since the hourly simulation reveals the charging

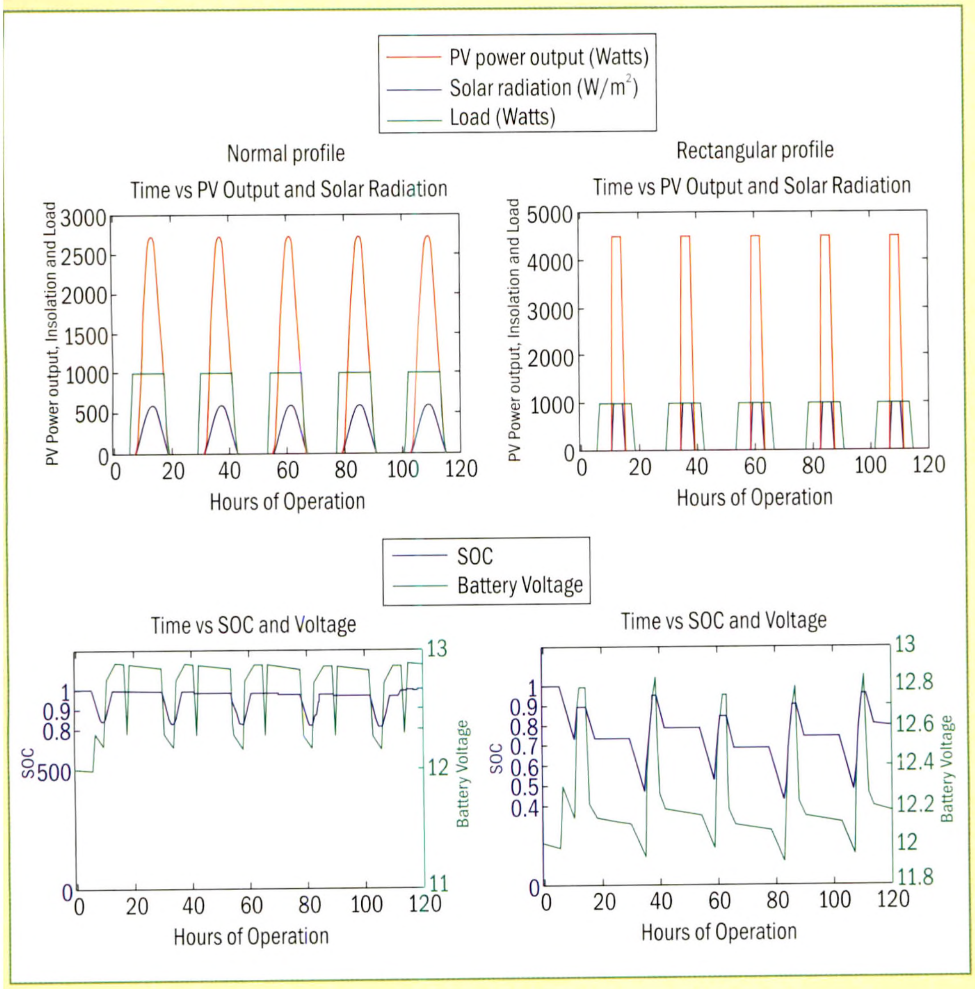


Figure 4: Comparison of performance parameters of a standalone PV system simulated using HGSR value and PSH value

and discharging pattern during each hour, this approach gives more realistic results. Hence, it is always recommended to adopt a design using hourly values of solar irradiation. Most of the designers find it difficult to obtain the hourly values due to cost issues or data availability issues. Therefore, a methodology is discussed in the next section to convert the PSH value to the hourly irradiation value.

HOURLY IRRADIATION VALUES FROM PSH

Is it possible to derive the hourly values of solar irradiation if PSH value is available? If yes, would it be a location-dependent methodology? The answer would be yes, and it is possible to do such conversions, provided the day length of that particular location is known. Let us see how it can be done.

A mathematical model is presented below which derives, but does not predict, the HGSR values for a given latitude with appreciable accuracy, from the Peak Sunshine Hours value. The model requires only two input parameters, Peak Sunshine Hours (h) and day length (q), which are easily available for any location. The analytical model is independent of location-dependent variables.

> IT IS POSSIBLE TO DESIGN THE SYSTEM USING PSH VALUE, WHICH RESULTS IN AN OVERSIZED SYSTEM. THIS, THOUGH, WILL ENSURE THE LEAST POSSIBLE LOSS OF LOAD HOURS, AND WILL ALSO CONTRIBUTE FOR HIGHER INVESTMENT. THE USE OF HOURLY SOLAR IRRADIATION WOULD GIVE A MORE ACCURATE AND PRECISE SIZING RESULT.

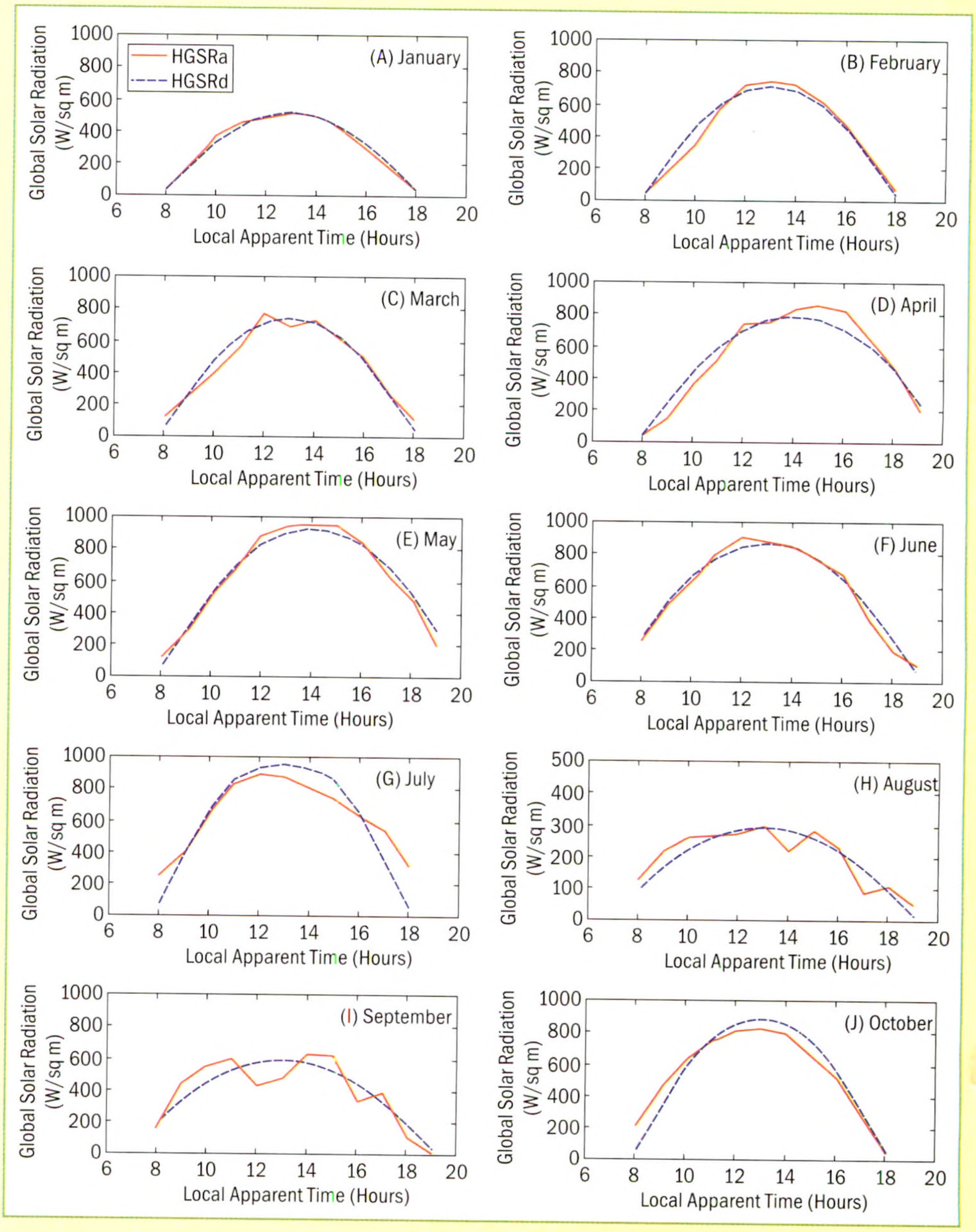
This makes the model more robust and simple. The HGSR of any hour 'hr' for any given day 'd' of the month 'm' is given by:

$$\text{HGSR (hr, d, m)} = \frac{6h}{q^3}x^2 - \frac{6h}{q^2}x$$

where

$$x = \begin{cases} 0 \;\forall\; hr < 12 - \frac{q}{2} \\ \left(hr + \frac{q}{2} - 12\right) \forall\; 12 - \frac{q}{2} \le hr \le 12 + \frac{q}{2} \\ 0 \;\forall\; hr > 12 + \frac{q}{2} \end{cases}$$

To justify the global applicability of the model, HGSR for New Delhi is derived and results are compared to the actual values. The comparison is shown in the Figure 5 (A-L).



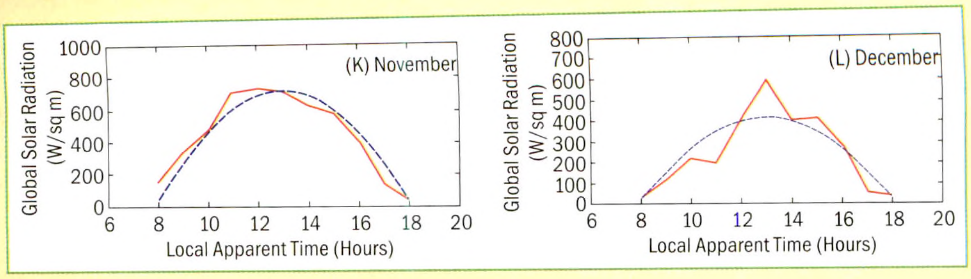


Figure 5: A comparison of actual and derived daily global solar irradiation for the average day of each month during the year 1995 for New Delhi, India

The derived values resemble the actual values for most of the month with a reasonable level of accuracy, with a correlation coefficient not less than 95 per cent. The maximum reported root mean square error in the comparison for New Delhi is 3.56 per cent. This method is useful for any solar application designer to derive the Hourly Global Solar Radiation of a given location for any given day with minimum available input data.

The highlight of this approach is that it requires only two input values. There were also some unavoidable limitations, for example, this model, being an analytical relation, could not follow the actual pattern during cloudy days when radiations are subjected to sudden fluctuations. But the derived values maintain a least error trend between the fluctuating proximities, as seen in Figure 5 (A-L).

CONCLUSIONS

PSH is only a virtual value used to quantify the total energy received from the sun at a specific irradiation value.

It is possible to design the system using PSH value, which results in an oversized system. This, though, will ensure the least possible loss of load hours, and will also contribute for higher investment. The use of hourly solar irradiation would give a more accurate and precise sizing result.

It is also possible to convert the PSH into its equivalent hourly values, with minimum errors, if day length and PSH of the given location are known. AU

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HYDROGEN FUEL FOR THE FUTURE

Hydrogen is considered to be a clean alternative fuel and the most viable energy carrier for the future. It can be used in internal combustion engines or fuel cells, producing virtually no greenhouse gas emissions when combusted with oxygen.

RENU SINGH, SAPNA TIWARI, MONIKA SRIVASTAVA

INTRODUCTION

Hydrogen can be produced from a variety of feedstocks. These include fossil resources, such as natural gas and coal, as well as renewable resources, such as biomass and water with electrical energy input from renewable energy sources (e.g., sunlight, wind, wave, or hydro-power). Pure hydrogen does not occur naturally; it takes energy to manufacture it. A variety of process technologies can be used, including chemical, biological, electrolytic, photolytic, and thermo-chemical, in its production. The non-polluting electricity produced from wind, solar, hydro, geothermal, and biomass, rather than fossil fuels, would be the preferred option for hydrogen production. Industrially hydrogen is produced mainly from fossil fuels, biomass, and electrolysis of water. Ninety percent of hydrogen is produced by steam reforming of natural gas or light oil fractions. The steam methane reforming process extracts the hydrogen from methane. However, this reaction causes an additional production of greenhouse gases such as carbon dioxide and carbon monoxide. Coal gasification and electrolysis of water are other industrial methods for hydrogen production. Local availability of feedstock, the maturity of the technology, market applications and demand, policy issues, and costs will influence the choice and timing of the various options for hydrogen production. Large-scale hydrogen production is possible only in the long term. In the short- and medium-term, the production options for hydrogen are based on distributed hydrogen production from the electrolysis of water and on the reforming of natural gas and coal.

BIOHYDROGEN ROUTES

Hydrogen produced biologically, most commonly by algae, bacteria, and archaea, is known as biohydrogen. Biohydrogen is a potential biofuel obtainable from both cultivation and waste organic materials. Biomass and waste streams can, in principle, be converted into biohydrogen with biomass gasification, steam reforming, or biological conversion methods such as biocatalysed electrolysis, or fermentative hydrogen production. Hydrogen is a key intermediate metabolite in ecosystems inhabited by a diverse group of photosynthetic and non-photosynthetic microbes. Hydrogenase and nitrogenase produce H_2 through four different processes occurring in different groups of organisms. These different hydrogen production processes have several advantages and disadvantages (Table 1).

> BIOLOGICAL HYDROGEN PRODUCTION (BHP) HAS THE POTENTIAL OF BEING A CLEAN ALTERNATIVE FOR H_2 PRODUCTION. BHP PROCESSES THAT UTILIZE MICRO-ORGANISMS THAT FREELY AND EFFICIENTLY PRODUCE H_2 AS A BY-PRODUCT DURING METABOLISM ARE MOSTLY OPERATED AT AMBIENT TEMPERATURES AND PRESSURES.

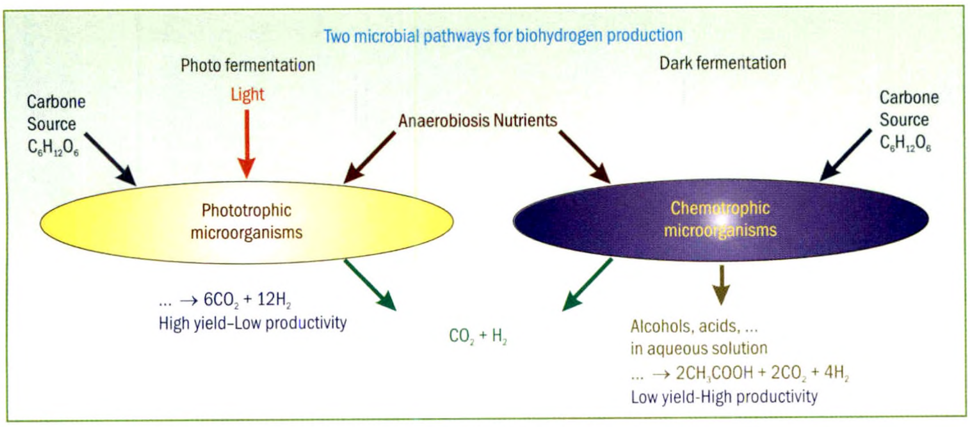
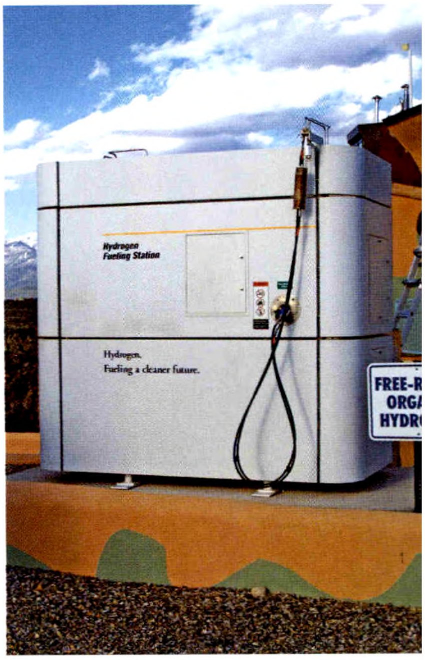

Two microbial pathways for biohydrogen production
Photo fermentation
Dark fermentation
Carbone Source $C_6H_{12}O_6$
Light
Anaerobiosis Nutrients
Carbone Source $C_6H_{12}O_6$
Phototrophic microorganisms
Chemotrophic microorganisms
... → $6CO_2 + 12H_2$
High yield-Low productivity
$CO_2 + H_2$
Alcohols, acids, ...
in aqueous solution
... → $2CH_3COOH + 2CO_2 + 4H_2$
Low yield-High productivity

Figure 1: General pathway of photo and dark fermentation

TABLE 1: Advantages and disadvantages of different H_2 production processes

Process	Advantages	Disadvantages
Thermo-chemical gasification	Maximum conversion can be achieved	Significant gas conditioning and removal of tar are required
Pyrolysis	Produces carbonaceous material along with bio-oil, chemicals, and minerals	Chances of catalyst deactivation
Solar gasification	Good hydrogen yield	Required effective collector plates
Supercritical conversion	Can process sewage sludge	Selection of supercritical medium
Microbial conversion	Can be operated at ambient temperature and pressure	Lower rate of hydrogen production and yield
Direct biophotolysis	Can produce H_2 directly from water and sunlight	Requires high intensity of light
	Solar conversion energy increased by ten-fold as compared to trees	O_2 can be dangerous for the system Lowered photochemical efficiency
Indirect biophotolysis	Cyanobacteria can produce H_2 from water	Uptake hydrogenase need to be removed
	Has the ability to fix N_2	About 30 per cent O_2 present in gas mixture
Photo-fermentation	Can use different organic wastes	O_2 inhibitory for nitrogenase
	A wide spectral light energy can be used	Light conversion efficiency low (1-5 per cent)

Hydrogen refilling station



Dark fermentation	It can produce H_2 all day long without light	O_2 inhibitor of hydrogenase
	A variety of carbon sources can be used as substrates	Relatively lower achievable H_2 yields
	Anaerobic processes, no O_2 limitation problem	As yields increases H_2 fermentation becomes thermodynamically unfavourable
		Product gas mix contains CO_2 that needs to be removed

> INDIRECT BIOPHOTOLYSIS IS THE SECOND BIOLOGICAL HYDROGEN PRODUCTION PROCESS WHERE H_2 PRODUCTION IS SPATIALLY OR TEMPORALLY SEPARATED FROM PHOTOSYNTHESIS AND BOTH HYDROGENASE AND NITROGENASE ARE SENSITIVE TO OXYGEN.

HYDROGEN PRODUCTION FROM WATER

Many technologies such as thermochemical, biochemical, and photochemical processes have been explored but have so far not found industrial applications. High temperature electrolysis of alkaline solutions has been used for the industrial scale production of hydrogen and there are now a number of small scale Polymer Electrolyte Membrane (PEM) electrolysis units available commercially. In thermochemical cycles, heat sources, in addition to chemical reactions, split water into hydrogen and oxygen components and the chemical compounds used in these processes are continuously recycled, for example, sulfur-iodine cycle, Copper–chlorine cycle, etc.

HYDROGEN PRODUCTION FROM FOSSIL FUELS

Hydrogen can be generated from natural gas or from other hydrocarbons to varying degrees of efficiency. Specifically, bulk hydrogen is usually produced by the steam reforming of methane or natural gas. At high temperatures (700–1100 °C), steam (H_2O) reacts with methane (CH_4) in an endothermic reaction to yield syngas. In the second stage, additional hydrogen is generated through the lower-temperature, exothermic, water gas shift reaction, performed at about 130 °C which also generates carbon dioxide (CO_2).

Hydrogen as option for clean fuel

TABLE 2: Various methods to produce hydrogen

Method	Process	Implementation
Steam reforming of methane gas	In presence of nickel catalyst at 700 – 1100 °C: $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$ Next reaction at lower temperature: $CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$	Current major source of hydrogen
Hydrogen from coal (Gasification)	At high temperature and pressure: $Coal + H_2O(g) + O_2(g) \rightarrow syngas$ $Syngas = H_2 + CO + CO_2 + CH_4$	Current method of mass hydrogen production
Electrolysis of water	Electric current passed through water: $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$	Not in widespread use due to cost of electricity
Solar – Hydrogen system	Electric current passed through water: $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$	Not in widespread use due to cost of renewable energy sources

Hydrogen production on a commercial scale

URRENT AND FUTURE SCENARIO

ydrogen is considered to be a clean alternative fuel and the most viable energy arrier for the future. It can be used in internal combustion engines or fuel cells, roducing virtually no greenhouse gas emissions when combusted with oxygen. Vater electrolysis and natural gas reforming are the technologies of choice in he current and near term. Hydrogen can be produced from most fossil fuels ut the complexity of the processes varies. Since carbon dioxide is produced as a y product, the CO_2 should be captured to ensure a sustainable (zero-emission) rocess. The feasibility of the processes will vary with respect to a centralized or istributed production plant. The production of hydrogen from biomass needs dditional focus on the preparation and logistics of the feed, and such production vill probably only be economical at a larger scale.

ONCLUSION

An alternative fuel must be technically feasible and economically viable, should asily convert to another energy form when combusted, be safe to use, and otentially harmless to the environment. Hydrogen is the energy carrier and uel of the future that can transform our fossil fuel-dependent economy into a ydrogen economy. Nevertheless, it is an energy carrier, not an energy resource. Hydrogen will ultimately be our environmental saviour, replacing the fossil fuels esponsible for global warming and various nagging forms of pollution. AU

Renu Singh, Sapna Tiwari, Monika Srivastava are from the Centre for Environment Science and Climate Resilient Agriculture, Indian Agricultural Research Institute. Email: renu_icar@yahoo.com

INVITING ARTICLES

AKSHAY URJA

The need to have a sustainable energy supply necessitates the exploration of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. RE can play an important role in resolving the energy crisis in urban areas to a great extent.

Today RE is an established sector with a variety of systems and devices available for meeting the energy demand of urban inhabitants, but there is a need to create mass awareness about their adoption. *Akshay Urja* is an attempt to fulfil this need through the dissemination of 20,000 copies (bilingual) in India and abroad. The magazine publishes news, articles, research papers, case studies, success stories, and write-ups on RE.

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CONSULTATION ON
THE PROPOSED NATIONAL WIND ENERGY MISSION

India has an estimated gross wind power potential of 102,000 MW (assessed at 80 m height), which has been arrived at with certain practical assumptions. This potential is mainly in the states of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Tamil Nadu. A total capacity of over 20,000 MW of wind power has so far been installed in the country. This success owes much to the concerted efforts of the Central government and State Governments in providing a conducive environment for the growth of wind power through private sector investment.

GOVERNMENT OF INDIA
MINISTRY OF NEW & RENEWABLE ENERGY
Consultation on
National Wind Energy Mission
ry 9, 2014, New
n with :

Dr Farooq Abdullah, Union Minister for New and Renewable Energy at the event

Recognizing the importance of wind power in India, the Planning Commission had recommended establishment of a National Wind Energy Mission in the 12th Five Year Plan. A concept note for the establishment of the Mission was accordingly prepared by MNRE after preliminary consultation with various stakeholders. In order to get the views and suggestions of various stakeholders face-to-face, a national consultation was organized by the Ministry on January 9, 2014 at the India Habitat Centre, New Delhi. The consultation was attended by industry representatives, state electricity regulators, State and Central Government officials, and R&D experts. A total of around 200 persons participated in the consultation. The one-day long consultation was divided into four sessions and broadly covered the following three issues:

- Scope of a wind energy mission with regard to potential, land availability, grid connectivity, clearance procedures, and zoning
- Long-term policy framework to incentivize large-scale deployment of wind sector
- Mechanisms for grid integration, balancing power, open access, and tariff determination for supporting aggressive wind power deployment

The consultation programme was inaugurated by Dr Farooq Abdullah, Union Minister for New and Renewable Energy.

Dr Abdullah, in his opening remarks, spoke about the development of offshore wind energy in the country. He mentioned that the potential of generating power through wind energy in the offshore areas was immense and the Ministry will approach the Union Cabinet soon for a decision. Dr S B Agnihotri, Secretary, MNRE highlighted the importance of setting up an Evacuation Infrastructure and short-term large scale storage facilities for the renewable energy. He also stressed on the need for making available long-term finance at reasonable rate for wind power producers. Dr Alok Srivastava, Joint Secretary, MNRE, mentioned in the concluding session that during the consultation a great number of ideas came out as to what can be the essential components of the proposed Mission, and some of these will be captured in the mission document.

Also present during the consultation were Shri R V Kanoria, Former President, FICCI; Smt. Neeraja Mathur, Chairperson, CEA, Shri Rakesh Sahni, Chairman, MPERC; Shri M R Sreenivasa Murthy, Chairman, KERC; Shri D Majumdar, CMD, IREDA; Shri Arunish Chawla, Planning Commission; Shri Sushanta Chatterjee, Joint Chief, CERC, and office bearers from prominent industry associations. AU

TERI with ADaRSH ORGANIZES THE 5th GRIHA SUMMIT 2014

Tarun Gogoi, Dr R K Pachauri, Dr Satish Balram Agnihotri

ADaRSH in association with TERI and the Ministry of New and Renewable Energy (MNRE), Government of India, conducted its fifth flagship event, the GRIHA Summit, starting January 16. The GRIHA Summit 2014 was a three-day summit attended by over 400 professionals from the building and construction industry. The Summit was an excellent platform to share knowledge in different provinces of the green building industry.

Speaking at the occasion, Guest of Honour, Tarun Gogoi, Chief Minister of Assam said, "I am very happy to grace this occasion. As an ordinary citizen, I am also concerned about climate change, and we have been experiencing this in my state (Assam) as well. I am glad we are working with TERI for taking the green buildings movement ahead. We need to use our resources efficiently for a sustainable future."

Special Guest, Dr Satish Balram Agnihotri, Secretary, MNRE, said, "Today 425 buildings are registered with GRIHA. We need to get into this exercise of making a certain amount of efficiency mandatory for those who are initially seeking support from the government, but eventually you need to get it as an enforcement system irrespective of whether they are receiving government support or not."

Dr R K Pachauri, Director-General, TERI, said "Given the growth in India's population and projected increases in income, it is estimated that a large share of the buildings that would be standing in 2030 are yet to be built. Buildings of various kinds consume huge quantities of energy, which could lock us into a pattern of energy and resource consumption extending several decades for the life of these buildings. Yet, we now know that with proper design, planning and construction, buildings can be made substantially more efficient in the use of energy, water, and other resources than what we see today. TERI has been at the forefront of promoting green and efficient buildings in the country, and the GRIHA Summit is a unique event where experiences on successful green buildings are shared, and plans and policies developed for the future."

Meanwhile, the event was also marked by an award ceremony. Pimpri Chinchwad Municipal Corporation was felicitated for exemplary commitment to implementation of sustainable habitat through the GRIHA platform.

During this event, TERI and ADaRSH launched the GRIHA PRAKRITI rating for existing schools. This would aim in creating a more sustainable education system by imparting environmentally ethical values among the students and the faculty.

NEW GEOTHERMAL PLANT DESIGN ENABLES EMISSION-FREE ENERGY PRODUCTION AND CARBON STORAGE

The idea stems from the fact that carbon dioxide extracts heat more efficiently than water thus, using it in a geothermal plant could generate more power and would also be a way to store carbon dioxide underground.

A research team from Ohio State University is proposing to expand the power generation capacity of geothermal projects ten fold while locking away unwanted carbon dioxide at the same time.

Geothermal power plants tap into hot water located deep underground, using the heat to generate power. The new design proposes to partially replace this heated water with carbon dioxide or another fluid.

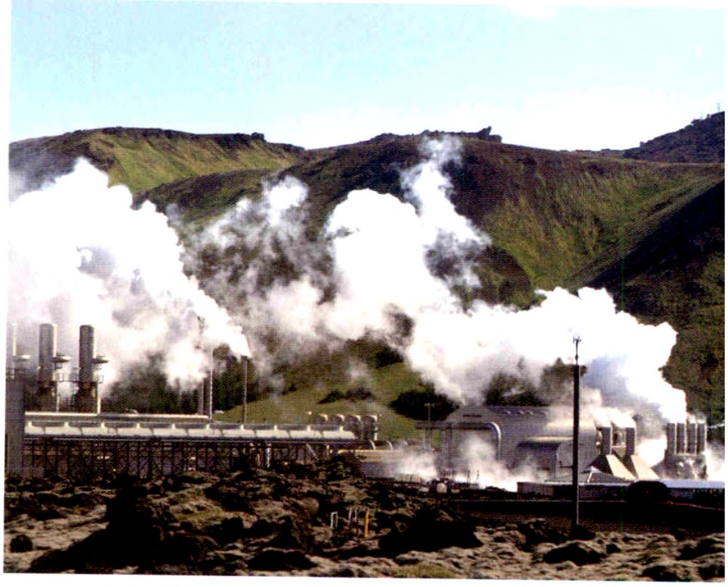
Carbon dioxide extracts heat more efficiently than water. Thus, using it in a geothermal plant could generate more power and would also be a way to store carbon dioxide underground.

In the new power plant design, a series of concentric rings of horizontal wells deep underground is filled with a mixture of carbon dioxide, nitrogen, and water. This mixture circulates through the rings, drawing heat from below ground up to the surface where it can then be used to power turbines to generate electricity.

The idea to use carbon dioxide this way was originally proposed by Martin Saar and others at the University of Minnesota.

The current research team includes researchers from the Ohio State University, University of Minnesota, and Lawrence Livermore National Laboratory, where geoscientist Tom Buscheck came up with the idea to add nitrogen to the mix.

Mr Buscheck and his colleagues believe that their multi-fluid design will enable a geothermal power plant to store energy for days or even months, so that it can produce power for the grid as needed. As it is underground, the system could also store carbon dioxide and nitrogen and keep them from entering the atmosphere.



Computer simulations of the system, using 10-mile-wide concentric rings located about three miles below ground produced around half a gigawatt of power — equivalent to a medium-sized coal power plant and around 10 times greater than the average geothermal plant.

The design calls for the geothermal project to be connected to a source of carbon dioxide, such as a power plant or factory. Carbon dioxide could be scrubbed and removed from the plant's emissions and sent to the geothermal project via pipeline.

In this way, the simulation saw the plant sequestering as much as 15 million tonnes of carbon dioxide a year, which is equivalent to the amount produced by three medium-sized coal-fired power plants in the same amount of time.

The design could also help geothermal power become possible in areas where underground hot springs are not that abundant. The use of carbon dioxide and nitrogen would decrease the amount of hot water needed by the plant.

Heat Mining Co. LLC, a startup company spun off from the University of Minnesota, expects to have an operational project based solely on using carbon dioxide and water by 2016.

Meanwhile, the team is continuing work on their design. They believe that the design could also work without carbon dioxide. The research team is working on a model that could initially be powered solely by nitrogen injection.

Aside from Mr Buscheck, the carbon dioxide, nitrogen, and water geothermal power plant design was developed by Jeffrey Bielicki, Assistant Professor of Energy Policy at OSU; Jimmy Randolph, a postdoctoral researcher in the Department of Earth Sciences at the University of Minnesota; and Mingjie Chen, Yue Hao and Yunwei Sun, all of L L N L.

The work was funded by the National Science Foundation and the US Department of Energy's Office of Energy Efficiency and Renewable Energy. AU

Source: www.ecoseed.org

Making a RHEOSTAT

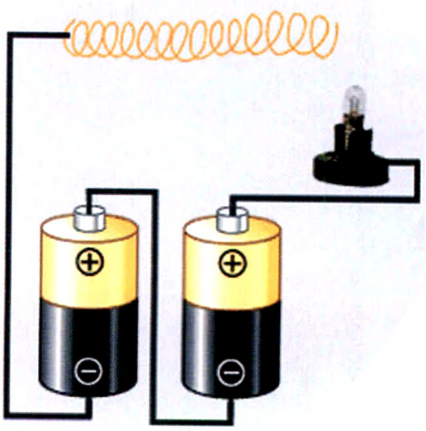
A small device that controls the voltage flow by a dial or knob

WHAT DO YOU NEED?

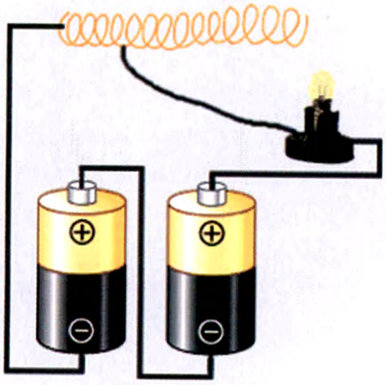
- A flashlight bulb and socket
- Two "D" cell batteries or a dry cell lantern battery
- About 16 inches of wire
- A piece of wire about 2 inches long
- A long, long spring — the spring from an inside roll up window will work great. You'll need to break open the wooden section that the shade rolls up on to get to the spring. Ask an adult to help you get this spring out.
- Pair of wire clippers

WHAT TO DO?

1. Connect the two batteries so the positive pole connects to the negative pole of the other battery.
2. Cut the 16-inch wire in half and attach each piece to the open end of the joined batteries.
3. Connect the free end of one wire to one terminal of the light socket.



Connect the other free wire to one end of the spring.



4. Connect the two-inch long wire to the other terminal of the light socket.
5. Connect the wire coming off the terminal to the end of the spring where the other wire is. Watch how brightly the bulb glows.
6. Now slowly move the short wire down the length of the spring. What happens?

WHAT YOU'LL DISCOVER!

As you go further away from the end where the wire is attached to the spring, the light will get dimmer and dimmer. The steel wire in the spring is not a very good conductor of electricity. The more wire the electricity has to pass through, the more resistance there is, and the less electricity. What you've made is called a rheostat. This is a device to vary the amount of a current passing through it to complete a circuit. AU

Source: http://www.energyquest.ca.gov/projects/rheostat.html

GREEN PRODUCTS

AMORIM EXPANDED-CORK BOARDSTOCK INSULATION

Most board stock insulation is plastic foam and contains halogenated flame retardants; some are made with blowing agents that are hundreds of times more potent than carbon dioxide in contributing to global climate change. Expanded Insulation Cork Board is 100 per cent natural, rigid insulation material produced from natural cork — bark from an oak tree native to the western Mediterranean region. Most of Amorim's cork forests are FSC-certified and the company's facilities are FSC chain-of-custody certified. The cork bark can be harvested from mature trees every nine years without damaging the trees. To produce rigid board stock insulation, cork granules are steam-heated in an autoclave, which expands the cork and activates a natural binder, suberin, contained in the cork; additional binders, flame retardants, or other chemicals are not used in production. Large billets are then cut into slabs as insulation. The material insulates to R-3.6 per inch, offers excellent acoustic control, is highly durable, has moderate vapour permeability, and meets fire-safety requirements (Euro Class E, based on EN 13501) without flame retardants. AU

Source: www.buildinggreen.com

To produce rigid boardstock insulation, cork granules are steam-heated in an autoclave

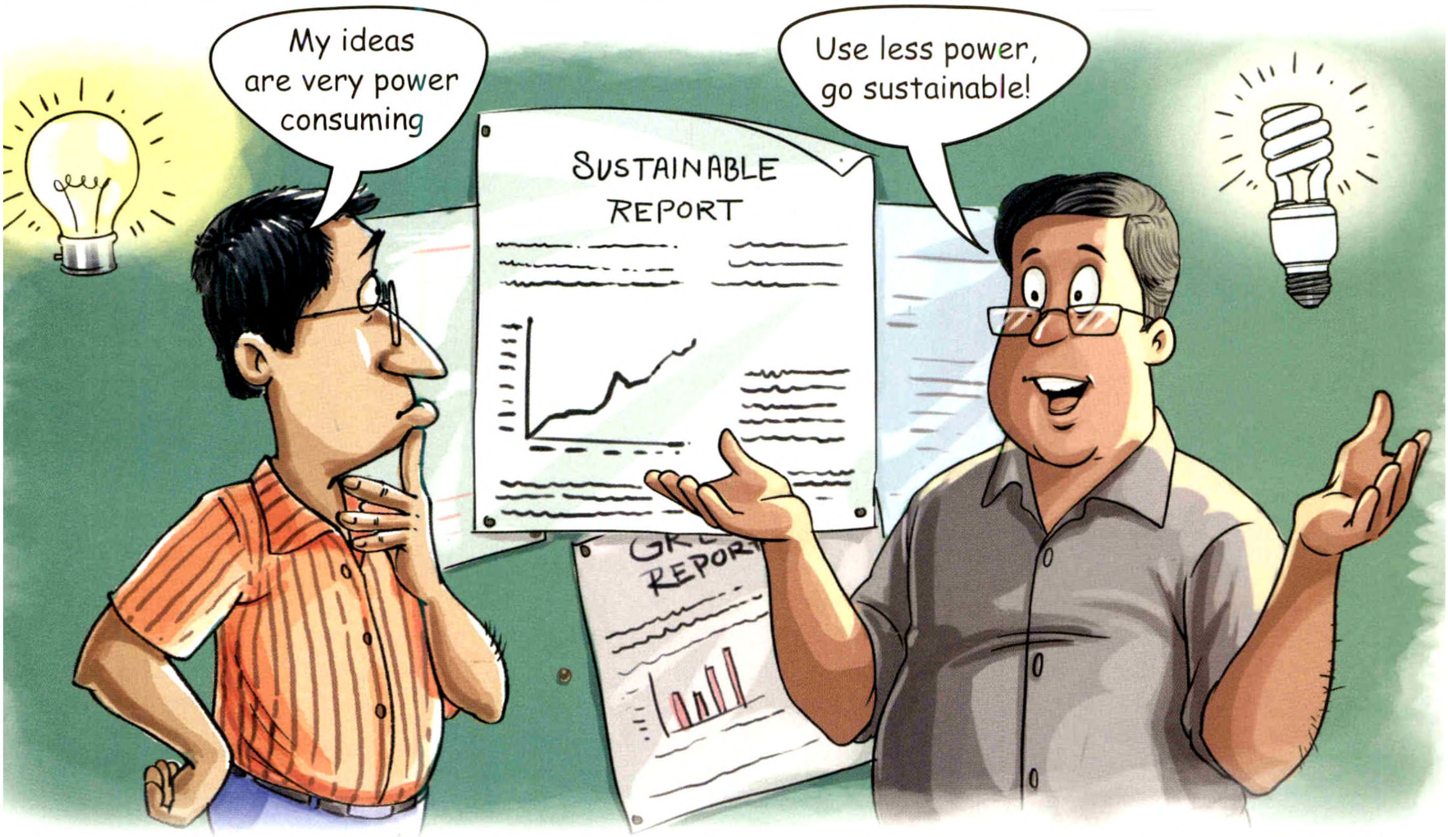

My ideas are very power consuming
Use less power, go sustainable!
SUSTAINABLE REPORT
GREEN REPORT

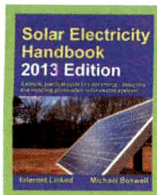
Illustration: Yatindra Kumar and Vijay Nipane

Web/Book Alert

WEBSITE

IRENA LAUNCHES FIRST-OF-ITS-KIND WEB PORTAL TO DEMYSTIFY RENEWABLE ENERGY COSTS

On the occasion of the sixth meeting of its Council in Abu Dhabi, the International Renewable Energy Agency (IRENA) launched a unique web portal dedicated to renewable energy cost analysis (www.irena.org/costs). The portal provides access to IRENA's data and analysis at no cost to users. The new portal showcases IRENA's position as the global source for cost and performance data of all renewable energy technologies. The web portal makes the latest and best cost data, as well as the agency's analysis, publications, presentations, and charts accessible to the public. It provides an important service for further development of renewable energy globally. Often, the lack of up-to-date, accurate, and reliable data on cost and performance was seen as a barrier to the uptake of renewable energy technologies. IRENA's new web portal ensures that this will not be the case in the future, and the debate about the role of renewable energy technologies in the energy sector can be based on the facts. The portal is accessible to the public at www.irena.org/costs, free for all users. AU

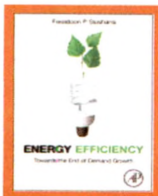


SOLAR ELECTRICITY HANDBOOK-2013 EDITION

Author: Michael Boxwell
Edited by Sheila Glasbey
Publisher: Greenstream Publishers
Paperback: 200 pages
ISBN-10: 1907670289
ISBN-13: 978-1907670282

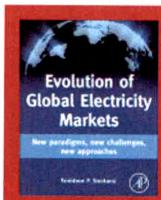
A Simple Practical Guide to Solar Energy: Designing and Installing Photovoltaic Solar Electric Systems

The 2013 edition of the *Solar Electricity Handbook* is a practical and straightforward guide to using photovoltaic solar panels to generate electricity. It is the seventh edition of the book, which has been updated yearly since 2009. The book explains how solar panels work, and how they can be used. It explains the steps you need to take to successfully design and install a solar electric system from scratch using photovoltaic solar panels. Accompanying this book is a solar resource website containing lots of useful information, lists of suppliers and online solar energy calculators that will simplify the cost analysis and design processes.



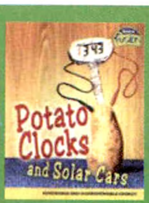
ENERGY EFFICIENCY: TOWARDS THE END OF DEMAND GROWTH

Author: Fereidoon Sioshansi
Hardbound: 688 Pages
Publisher: Academic Press
ISBN: 978-0-12-397879-0



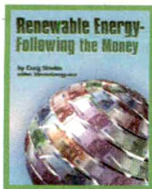
EVOLUTION OF GLOBAL ELECTRICITY MARKETS: NEW PARADIGMS, NEW CHALLENGES, NEW APPROACHES

Author: Fereidoon Sioshansi
Publisher: Academic Press
Hardbound: 880 Pages
ISBN: 978-0-12-397891-2



POTATO CLOCKS AND SOLAR CARS: RENEWABLE AND NON-RENEWABLE ENERGY

Author: Elizabeth Raum
Publisher: Raintree (2007)
ISBN-13:9781410928665
ISBN-10:1410928667
Paperback: 32 Pages



RENEWABLE ENERGY - FOLLOWING THE MONEY

Author: Craig Shields
Publisher: Clean Energy Press (2013)
ISBN-13 9780615789439
ISBN-10:0615789439
Paperback: 318 Pages

The book is a follow-on to Craig's first two book projects: *Renewable Energy–Facts and Fantasies* — published in 2010, a survey of the technology, the economics, and the politics associated with clean energy, and *Is Renewable Really Doable?* — published in 2012, a "deeper dive" into the issues preventing us as a civilization from migrating to a safe and sane energy policy. In *Following the Money*, Shields presents another set of interviews, these associated with the effects that economics and financial power have on the course of the energy industry.

Forthcoming Events

INTERNATIONAL

5th Annual Renewable Energy Finance and Infrastructure Summit

February 5th to 6th, 2014

Frankfurt, Germany
Organized by: Fleming Europe
Contact person: Ada Tobias
Website: http://energy.flemingeurope.com/renewable-energy-summit?utm_source=listing_conferencealerts&utm_medium=listing&utm_campaign=BAEN67_home

International Conference on Intelligent Agriculture (ICOIA 2014)

February 13th to 14th, 2014

Hong Kong, China
Organized by: IACSIT
Contact person: ICOIA Editor
Website: http://www.icoia.org/

5th International Conference on Environmental Science and Development - ICESD 2014

February 19th to 20th, 2014

Singapore
Organized by: CBEES
Contact person: Issac Lee
Website: http://www.icesd.org/

The Deeper Water Offshore Wind Conference – Driving Costs Down

March 5th, 2014

London, United Kingdom
Contact person: Claire
Website: http://www.offshorewindconference.com

The 2nd Biennial Conference on Sustainable Business, Energy and Development in Asia (COSA 2014)

March 17th to 19th, 2014

Hiroshima, Japan
Organized by: PRESDA Foundation
Contact person: COSA Secretariat
Website: http://www.presdafoundation.org/sustainable-business-conference/proposals

2nd International Conference on Research in Science, Engineering and Technology (ICRSET 2014)

March 21st to 22nd, 2014

Dubai, United Arab Emirates
Organized by: International Institute of Engineers
Contact person: Conference Secretary-ICRSET'2014
Website: http://www.iieng.org/2014/03/24/46

Solar Energy Africa 2014

March 4th to 5th, 2014

Nairobi, Kenya
Organized by: Solar Media
Contact person: Sue Bradshaw
Website: http://africa.solarenergyevents.com/

NATIONAL

International Conference on Research Trends in Energy Internet - 2014 (ICRTEI-2014)

February 14th to 15th, 2014

Bangalore, Karnataka, India
Organized by: Computer Society of India–Bangalore Chapter
Contact person: Senthil Kumar
Website: http://www.csibc.org/ICRTEI2014/

1st International Congress on Environmental, Biotechnology, and Chemistry Engineering (CEBCE 2014)

February 21st to 23rd, 2014

Pune, India
Organized by: SAISE
Contact person: Carina Liu
Website: http://www.saise.org/cebce2014

International Conference on Renewable Energy (ICRE 2014)

Contact person: Zeke Zhou
Website: http://www.saise.org/icre2014

International Conference on Industrial Engineering and Applications (ICIEA 2014)

March 17th to 18th, 2014

Chennai, India
Organized by: SAISE
Contact person: Zeke Zhou
Website: http://www.saise.org/iciea2014

International Conference on Power and Energy Engineering (ICPEE 2014)

March 17th to 18th, 2014

Chennai, India
Organized by: SAISE
Contact person: Zeke Zhou
Website: http://www.saise.org/icpee2014 AU

RENEWABLE ENERGY AT A GLANCE IN INDIA

Sector	Target		Achievements during the Month of December		Achievements during the Year (up to Dec-2013)		Cumulative Achievements	
	2012-13	2013-14	2012-13	2013-14	2012-13 (% of Target)	2013-14 (% of Target)	(as on 31.12.2013)	(as on 31.12.2013)
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)								
Wind Power	2500.00	2500.00	99.30	51.05	1067.75 (42.71%)	1096.50 (43.86 %)	18420.40	20149.50
Small Hydro Power	350.00	300.00	31.55	9.00	100.83 (28.80 %)	130.90 (43.63 %)	3496.14	3763.15
Biomass Power & Gasification	105.00	105.00	6.00	1.00	98.50 (93.81 %)	21 .00 (20 %)	1248.60	1284.60
Bagasse Cogeneration	350.00	300.00	40.40	120.40	254.40 (72.68 %)	175.45 (58.48 %)	2239.63	2512.88
Waste-to-Power	20.00	20.00	2.40	0.00	6.40 (32 %)	3.00 (15 %)	96.08	99.08
Solar Power	800.00	1100.00	129.09	79.00	234.97 (29.37 %)	495.13 (45.01 %)	1176.25	2180.00
Total	4125.00	4325.00	308.74	260.45	1762.85 (42.73 %)	1921.98 (44.43 %)	26677.10	29989.21
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)								
Waste-to-Energy	20.00	10.00	2.50	1.06	11.86 (59.30 %)	4.06 (40.60 %)	113.60	119.63
Biomass (non-bagasse) Cogeneration	60.00	80.00	2.10	13.00	43.53 (72.55 %)	38.54 (48.17 %)	426.04	509.69
Biomass Gasifiers -Rural	1.50	1.00	0.064	0.192	0.576 (38.40 %)	0.35 (35 %)	16.696	17.05
-Industrial	10.00	9.00	0.250	1.05	4.82 (48.20 %)	2.88 (32 %)	138.90	141.67
Aero-Generators/Hybrid Systems	0.50	1.00	-	0.01	0.10 (20 %)	0.04 (4 %)	1.74	2.15
SPV Systems	30.00	40.00	2.52	5.40	16.12 (53.73 %)	19.70 (49.25 %)	106.33	144.38
Water Mills/Micro Hydel	2.00 (500 nos)	2.00 (500 nos)	-	1.66 (416 nos)	0.27 (13.50 %) (68 nos)	1.66 (83 %) (416 nos)	8.48 (2121 nos)	10.18 (2547 nos)
Biogas-based Energy System	2.00	2.00	-	-	-	-	-	-
Total	126.00	145.00	7.434	22.37	77.276 (61.33 %)	67.23 (46.36 %)	811.790	944.75
III. OTHER RENEWABLE ENERGY SYSTEMS								
Family Biogas Plants (numbers in lakh)	1.25	1.10	0.40	0.20	0.40 (32 %)	0.50 (45.45 %)	45.86	47.10
Solar Water Heating – Coll. Areas (million m^2)	0.60	0.60	0.10	0.10	0.71 (118.33 %)	0.47 (78.33 %)	6.17	7.47

Volume 7 • Issue 5 • April 2

सत्यमेव जयते

Ministry of New and Renewable Energy
Government of India

Renewable Energy
Akshay Urja

www.mnre.gov.in

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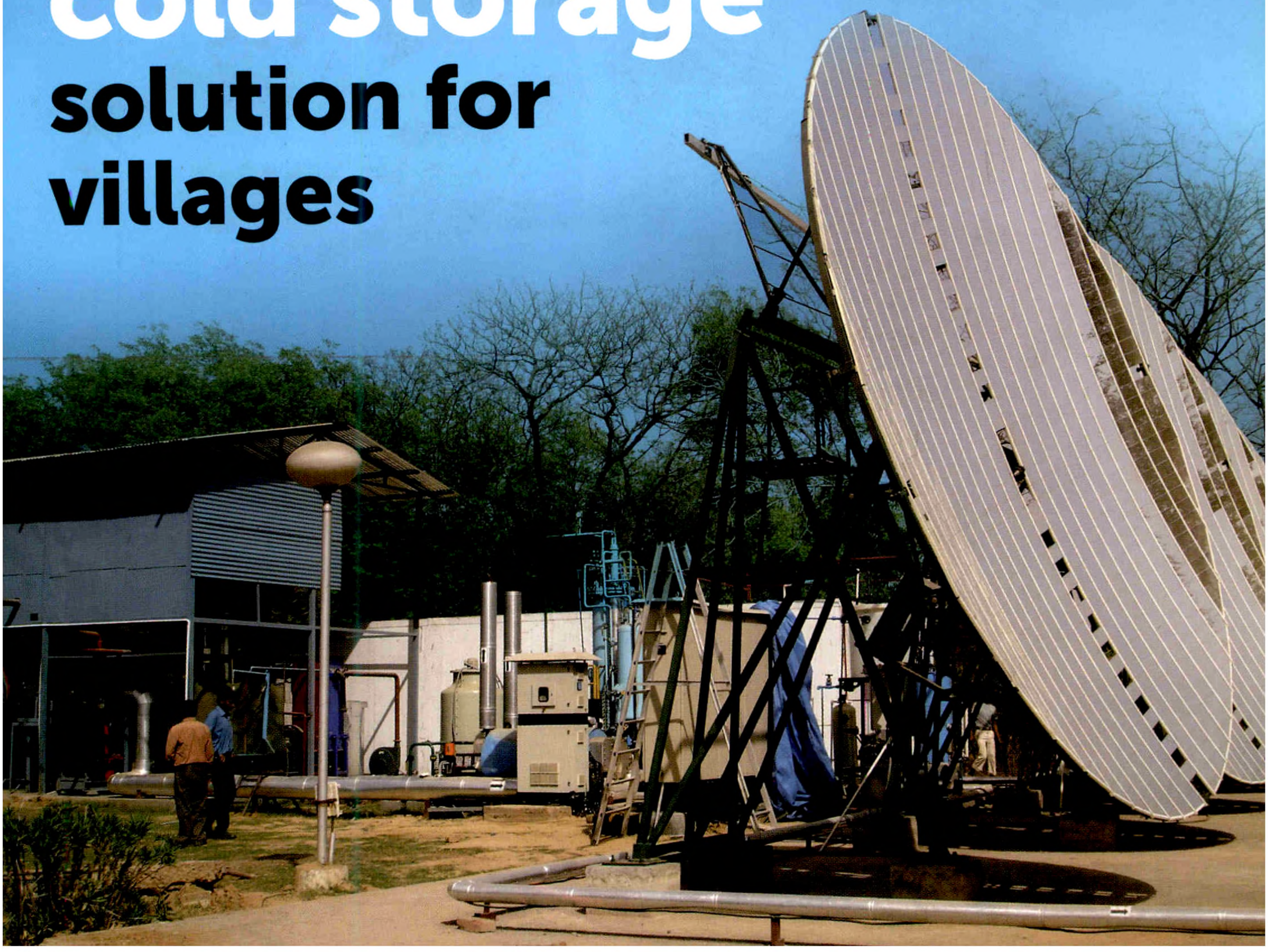
Small
Wind Energy and Hybrid Systems

Arrived cold storage solution for villages



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5th WORLD RENEWABLE ENERGY TECHNOLOGY CONGRESS

INTERNATIONAL CONFERENCE AND EXHIBITION

21 - 23 AUGUST 2014 I EXPO & CONVENTION CENTRE
MANEKSHAW CENTRE, NEAR IGI AIRPORT, DELHI, INDIA

THEME: Renewable Energy and Energy Efficiency: Empowering Sustainable Tomorrow

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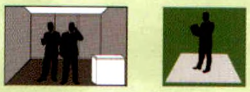

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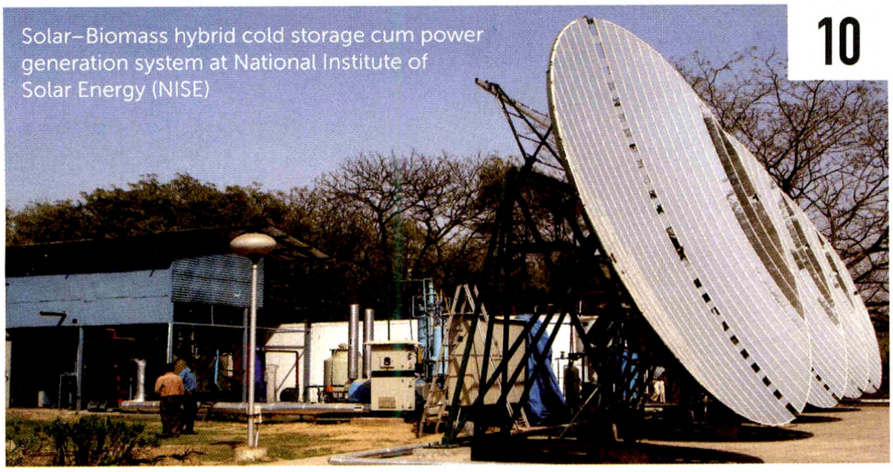
Renewable Energy Akshay Urja


Solar–Biomass hybrid cold storage cum power generation system at National Institute of Solar Energy (NISE)

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Upgrading and bottling of biogas, a renewable energy source, can help in both waste management and building a sustainable environment. **Virendra Kumar Vijay** writes about the on-going research developments in the field.

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Read on as **J P Singh** and **Hari Bhaskaran** take you through the nascent market for Small Wind Turbines and Small Wind–Solar Hybrid Systems in India and the role of the Ministry of New and Renewable Energy in promoting the scheme.

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CSP seems to be one of the most promising technologies that can help meet the growing demand for energy in the country. **Nakul Varier** and **Rutuja Londhe** look into the various facets of this technology while focusing especially on power generation though the Parabolic Trough.

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(Published in English and Hindi)

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Ministry of New and Renewable Energy

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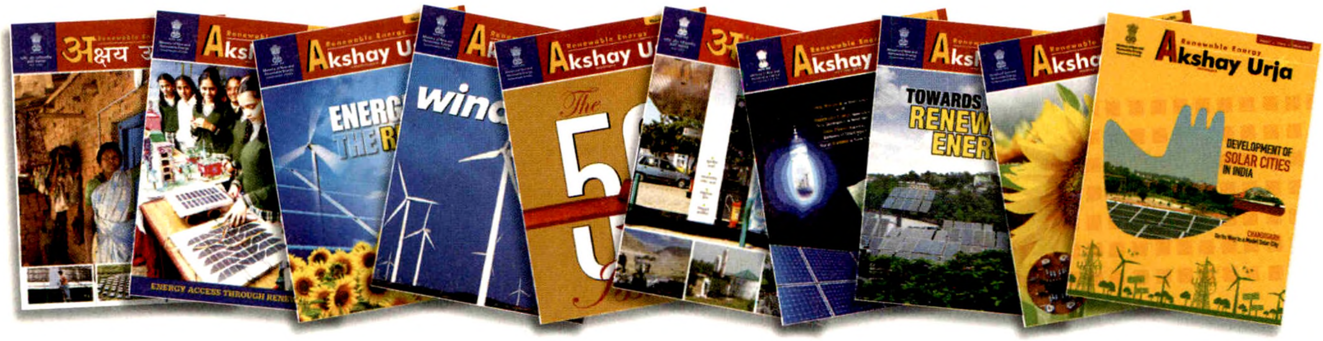

It is our kind pleasure that we are receiving a bi-monthly newsletter Akshay Urja of Ministry of New and Renewable Energy, Government of India published in English. Akshay Urja magazine is found very relevant, informative and interesting. We are running course of B.Tech (Renewable Energy and Environmental Engineering) at Saradarkrushinagar, Agricultural University, Dantiwada. It is very useful for our students to carry out their final year project as well as other relevant information regarding renewable sources in India and its development projects. Akshay Urja magazine will help us to learn and popularize new and Renewable Energy Technology among rural people and students. We therefore request you to send 10 copy of newsletter regularly. We shall also send you an e-mail for your kind information.

Thanking you in advance for your positive response.

I/C Dean
College of Renewable, Energy and
Environmental Engineering
Sardar Krushinagar Dantiwada
Agricultural University

I enjoyed reading through Akshay Urja magazine on various renewable energy technologies like Biomass, Wind, Bio-gas, Geothermal, Hydro and Solar Photovoltaic technologies/systems which are the major sources of renewable energy in the power sector. This magazine provides us the latest information about the various renewable energy technologies. This magazine is very informative and useful for the students and new researchers. Akshay Urja magazine is very useful for me, please send me regularly 2 copy (1 English and 1 Hindi) both versions of Akshay Urja magazine.

Pratap Singh
Panchwati, Loni

नवीन एवं नवीकरणीय ऊर्जा मंत्रालय, भारत सरकार द्वारा प्रकाशित हिन्दी पत्रिका 'अक्षय ऊर्जा' के माध्यम से आप वह कार्य कर रहे हैं जिससे आने वाले समय में ऊर्जा की समस्या हल हो सकेगी। आपसे प्रेरणा लेकर हमारी संस्था सौर ऊर्जा का प्रचार एवं प्रसार करने में सतत् प्रयत्नशील है।

श्रीमती अंजनी रस्तोगी
अध्यक्ष, अरविन्द महिला विकास क्लब
समिति, मढ़ई चौक, बयायूँ (उ.प्र.)

आपकी पत्रिका 'अक्षय ऊर्जा' पढ़ने को मिली, पढ़कर बड़ी खुशी हुई क्योंकि इस में प्राकृतिक संसाधानों को बचाने एवं ऊर्जा के नए स्रोतों को काम में लाने के बारे में बताया गया है। इस पत्रिका के आने से सौर ऊर्जा, पवन ऊर्जा एवं जैविक ऊर्जा के क्षेत्र में मंत्रालय द्वारा किए जा रहे विभिन्न कार्यो की पूरी जानकारी मिलती है जिससे हमारे सतना जिले के सभी निवासियों को भी लाभ होगा।

दीपक कुमार बधौलिया
अक्षय ऊर्जा शॉप (यू.एस. सेल्स कॉर्पोरेशन)
राजेन्द्र नगर, सतना (मध्य प्रदेश)

आपके द्वारा सम्पादित पत्रिका 'अक्षय ऊर्जा' की एक प्रति इस महाविद्यालय को लगातार प्राप्त होती रहती है। इस पत्रिका के माध्यम से महाविद्यालय को सौर ऊर्जा, पवन ऊर्जा और बायोमास से संबंधित विस्तृत जानकारी प्राप्त होती है। पत्रिका में मुद्रित लेख, शोध कार्य और आंकड़े विद्यार्थियों के लिए लाभकारी होते हैं। विगत् अंक में ''चंडीगढ़: एक आदर्श सौर शहर की ओर'' लेख बहुत पसंद आया, इसके लेखक श्री संतोष कुमार जी बधाई के पात्र हैं।

डॉ. आर. के. गौतम (प्राचार्य)
स्वामी द्वारकादास कला एवं वाणिज्य
महाविद्यालय, ढीमरखेड़ा, मध्य प्रदेश

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of *Akshay Urja* will make every effort to make this magazine highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in content and presentation.

Editor, *Akshay Urja*

Dear Readers,

A hybrid system is a combination of two or more systems which are complementary to each other and provide the constant supply of output. The relevance of renewable energy based hybrid systems increases so as to provide constant energy output. The renewable energy based hybrid systems may have a combination of solar–wind system, solar–diesel generators, dual fuel engine generators working with biogas-diesel, bio fuel-diesel, producer gas-diesel, solar thermal-conventional boilers for steam generation, wind–diesel generators, solar thermal-electricity based water heaters, etc. Solar-based battery operated vehicles, solar–diesel based vehicles, and battery-operated vehicles charged with solar and conventional electricity, etc., are few examples of hybrid vehicles. There could be more combinations of hybrid systems.

Solar–wind based hybrid systems with small aero generators have been very well received and are popular in the country. Aero generators up to 100 kW can be used in combination with an appropriate solar PV system. The World Institute of Sustainable Energy, Pune, has estimated a potential of 83,000 MW in a study conducted in 2009, against which only about 2.10 MW has been harnessed so far. One such system installed with the combination of 69.33 kW solar and 85.5 kW of wind aero generator at 'One Earth' building of Suzlon in Pune is a good example for others to follow the suit. Although, there is ample scope to harness the potential of solar–wind hybrid systems, yet very little has been done and I feel that this sector needs more focused attention.

The biomass gasifier and solar thermal based hybrid cold storage is another unique development in this direction. The system can be seen working in the National Institute of Solar Energy, Guwal Pahari, Gurgaon. This could be an alternative to the conventional cold storages in rural areas. Biogas–CNG or biogas–diesel based vehicles have also shown good results. There is a need to come out with the simple, suitable, and user-friendly policy in this direction. Solar water heaters with the option of heating water during non-sunny days with electricity have been in use, quite for some time. Thus, a hybrid system is more acceptable and reliable.

There is a need to promote the renewable energy based hybrid systems through clear policies. I would also make an appeal to the manufacturers to develop more such systems and make them available in the open market.

We are overwhelmed with the response of our readers. You will be happy to note that Akshay Urja has successfully completed a journey of nine years and has entered in its 10th year now. This could have not been possible without the active response and support of our readers, colleagues in the Ministry, and the contribution of each member of the editorial board.

With best wishes and an appeal to spread the use of renewable energy,

AKTripathi

ARUN K TRIPATHI
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अक्षय ऊर्जा से देश विकास
सूरज एक रूप अनेक

RENEWABLE ENERGY NEWS

PRIME MINISTER INAUGURATES 'INDIRA PARYAVARAN BHAWAN': INDIA'S FIRST ON-SITE NET ZERO BUILDING

Dr Manmohan Singh, Prime Minister of India, on 25 February 2014, dedicated to the nation 'Indira Paryavaran Bhawan' in the presence of Dr M Veerappa Moily, Minister for Environment and Forests (MoEF) and Shri Jairam Ramesh, Minister for Rural Development. The centrally air-conditioned office building which has provision to accommodate about 600 officials of the MoEF is located at Jorbagh Road, New Delhi.

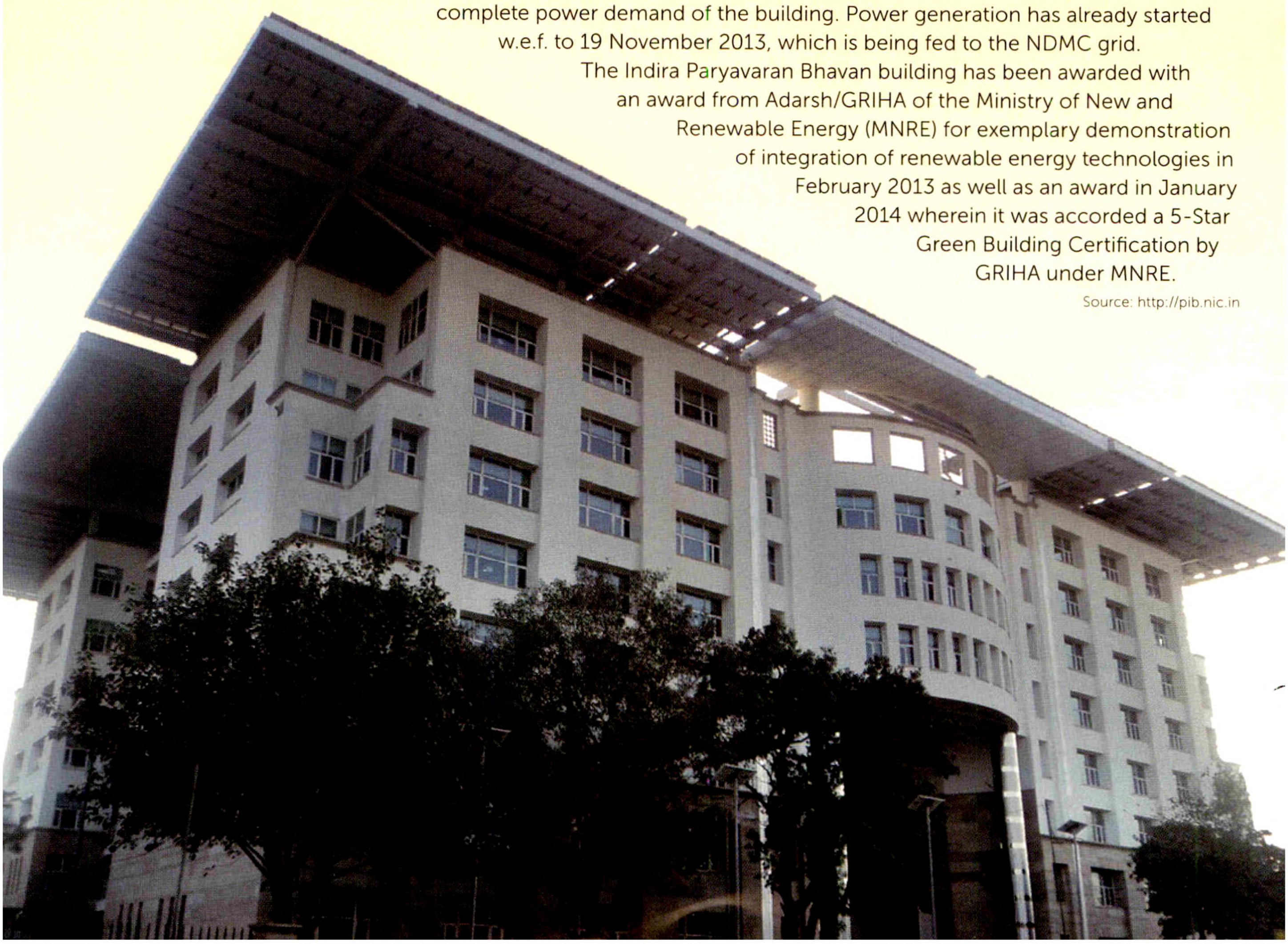
The Indira Paryavaran Bhawan is India's first on-site Net Zero Building built by adoption of solar passive design and energy-efficient building material. This building is expected to be a trendsetter in the country that shall inspire people towards adoption of green technology. The building has been designed with the highest Green rating, i.e., GRIHA 5-Star and LEED India Platinum.

The cost of the project is about Rs 209 crore including the cost of land, solar photo voltaic power generation, and its evacuation system as well as a three-level mechanized basement parking air-conditioning system, supported by geothermal cooling, IT services, audio and video system in auditoriums and committee rooms, furniture, provision for horticulture, and other services. The building has an earthquake-resistant structure with a total plinth area of 31,488 sq. m. The building covers only 30 per cent of the plot area. More than 50 per cent area, outside the building, is a soft area with many plants and grass patches. Even circulation roads and pathways are soft areas to enable groundwater recharge.

The robotic parking system in the basement can accommodate 330 cars. Provisions have been made for a cafeteria roof garden, as well as a gymnasium and yoga room for recreation and wellness of the employees. The office has been furnished with modular furniture and work stations. A thin client networking system has been provided instead of conventional desktop computers to minimize energy consumption. A solar power generation system has been provided at the terrace level, by creating a 6,000 sq.m. support area, for meeting with the complete power demand of the building. Power generation has already started w.e.f. to 19 November 2013, which is being fed to the NDMC grid.

The Indira Paryavaran Bhavan building has been awarded with an award from Adarsh/GRIHA of the Ministry of New and Renewable Energy (MNRE) for exemplary demonstration of integration of renewable energy technologies in February 2013 as well as an award in January 2014 wherein it was accorded a 5-Star Green Building Certification by GRIHA under MNRE.

Source: http://pib.nic.in



DELHI METRO TO INSTALL ROOF TOP SOLAR POWER PLANT

The Delhi Metro Rail Corporation (DMRC) is all set to become the first ever metro system in the country to install 'Roof Top Solar Power Plants' at its metro stations. The first ever such plant with a production capacity of 500 kWp will be installed at the Dwarka Sector 21 metro station.

A Power Purchase Agreement (PPA) regarding the installation of the plant was signed between DMRC and the developer, a multinational firm engaged in the installation and production of solar power worldwide, in the presence of DMRC's Managing Director, Sh. Mangu Singh and other senior officials of DMRC.

This is the largest roof top plant with such capacity in Delhi NCR region under the RESCO model.

Under this model, the DMRC will pay for the units generated by the plant and the capital investment shall be provided by the developer. The plant is expected to start production within a period of six months. The power produced from this plant will be used to cater to the power requirements of DMRC at this station.

After the installation of this roof top plant, DMRC will also explore the possibility of installing more such plants at its stations, depots, parking lots as well as residential complexes. Efforts are also being made to integrate such solar plants with the station structures of Phase 3.

Source: http://articles.economictimes.indiatimes.com

15 MW RICE HUSK BASED BIOMASS PROJECT IN UTTAR PRADESH

An innovative biomass-based power plant, established in Fatehullar village of Ghazipur, is bolstering the integrated agri-processing and enhancing the rural economy in the state. The power plant is a first-of-its-kind in UP. The plant ensures maximum utilization of crop wastes.

The start of the 15 MW capacity power plant has also brought a new concept in paddy processing and rice milling while utilizing husk as fuel as a clean and renewable source of energy. "The power plant has already achieved the power load factor (PLF) of 99.94 per cent in the very first year of its commercial operation in 2010", said M L Arora, General Manager of a Ghazipur-based agro-energy company which has established the power plant.

The company plans to set up Biomass Collection Centres (BCCs) at various locations in the state where farmers can get value for their agro-waste that was earlier burnt in the field.

Mr Shyam Lal, Chairman of Planner India Limited, said that Goshandepur village under Karanda block in Ghazipur district is already witnessing successful operation of power crops centre. A number of districts in east UP region such as Jaunpur, Mirzapur, Chandauli, and Buxar (Bihar) are in the pipeline to get such centres soon. These centres have great potential for enhancing rural employment and economy besides adding value to agri-businesses for small and marginal farmers, he added. He also said that such centres would be opened at more places in the country, beginning with UP and Bihar.

Successful projects like these have evolved a model of feedstock security and supply which is essential to success of the project. Also, the government is launching a new policy initiative of small biomass plants of 1 to 2 MW at the tail-end with a target of 10,000 MW in the next 10 years.

Source: http://panchabuta.com

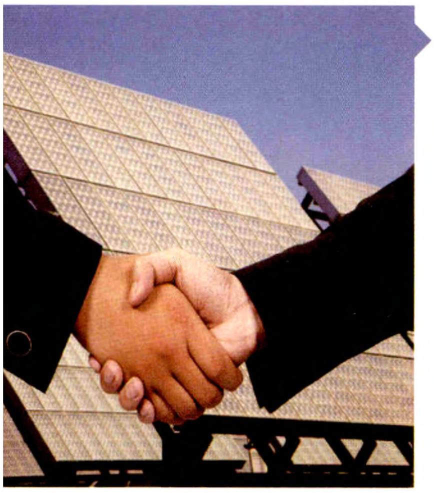
PROJECTS SELECTED FOR JNNSM PHASE II BATCH

The Solar Energy Corporation of India has published the list of bidders selected for Grid Connected Projects under Phase II Batch I of Jawaharlal Nehru National Solar Mission (JNNSM) through an open bidding process. Projects with a total capacity of 375 MW each in the DCR and Open Categories have been allocated after a two-stage techno-commercial and financial evaluation process based on Viability Gap Funding mechanism. Some of the major highlights of the Phase II Batch I allocations are as follows:

- A total of 47 projects — 22 in the DCR (Part A) and 25 in the Open (Part B) have been selected
- The VGF sought per MW ranges from Rs 1.35 crores to Rs 2.456 crores in the DCR (Part A) category and from Rs 0.175 crores to Rs 0.135 crores in the Open (Part B) category
- Like in the first Phase of the JNNSM, Rajasthan continues to be the favourite destination for Solar Power Developers for setting up solar power plants where maximum number of projects (and maximum installed capacity) are proposed to be located in the second Phase too
- Followed by Rajasthan, Madhya Pradesh will see the maximum addition in solar power generation capacity through JNNSM Phase II allocations
- The total VGF to be disbursed by the government in the second phase of JNNSM is nearly Rs 400 crores in the open category (Part B) and approximately Rs 800 crores in the DCR category

The LoIs to the selected bidders are to be sent soon and PPAs are expected to be signed as well.

Source: http://www.solarguidelines.in



INDIA AND SUDAN AGREE TO PROMOTE COOPERATION IN RENEWABLE ENERGY

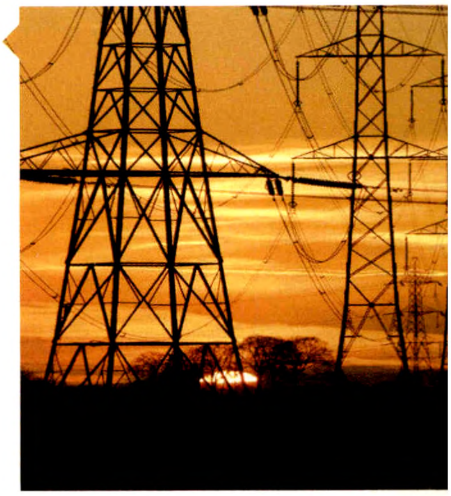
Union Minister of New and Renewable Energy, Dr Farooq Abdullah held a bilateral meeting for promoting cooperation in renewable energy with a delegation from Sudan. The Sudanese delegation was led by Mr Al Simah Al Siddiq Al Nour, Minister of Industry. He along with other members including Mr Magdi Hassan Yasin, State Minister of Finance and National Economy from Republic of Sudan met Dr Abdullah to discuss ways of enhancing cooperation in promoting renewable energy between the two countries.

Dr Abdullah acknowledged that India and Sudan have good potential for enhancing cooperation in promoting renewable energy and offered to provide Indian assistance for developing renewable energy resources in Sudan. The talks focused on the areas of possible cooperation especially in the development of wind energy, solar energy, biomass, and small hydro resources. It was also agreed that Ministry of New and Renewable Energy would provide support for resource assessment and training in the areas of wind and solar energy through its technical institutions viz. Centre for Wind Energy Technology, Chennai and the National Institute of Solar Energy, Gurgaon.

Indian Renewable Energy Development Agency (IREDA), the Indian green energy financial institution would provide knowledge and technical appraisal assistance in developing renewable energy projects on commercial basis. A team comprising officials from Ministry of New and Renewable Energy, IREDA, CWET and NISE would soon visit Sudan to discuss a framework for further cooperation between the two countries.

Source: http://www.business-standard.com

INDIA TO REDUCE ENERGY IMPORT DEPENDENCE TO 21 PER CENT IN 2047 AT OPTIMAL LEVELS: INDIA ENERGY SECURITY SCENARIOS (IESS) 2047 WEBSITE LAUNCHED



India's import dependence on the energy front can be lowered to 21 per cent in 2047 at its most optimal level from the current level of 31 per cent, provided India takes corrective steps towards pricing that supports energy efficiency and establishes the appropriate regulatory mechanism. This has been projected in the study made under different Scenarios as part of IESS 2047.

The tool (IESS) 2047 was launched by the Planning Commission in partnership with the Confederation of Indian Industry in New Delhi. It was developed by the Planning Commission in consultation with key stakeholders including the UK Department of Energy and Climate Change, TERI, C-Step, and Prayas Energy. It shows various combinations of energy demand and possible energy supply pathways available to the country ranging from the least effort to the heroic effort.

The IESS 2047 is an energy scenario building tool which generates the energy demand and supply scenarios for India leading up to the year 2047. The demand and supply scenario for the year 2047 has been projected under four different scenarios: Least Effort" Scenario, "Determined Effort" Scenario, Aggressive Effort" Scenario, and Heroic Effort" Scenario.

Source: http://pib.nic.in

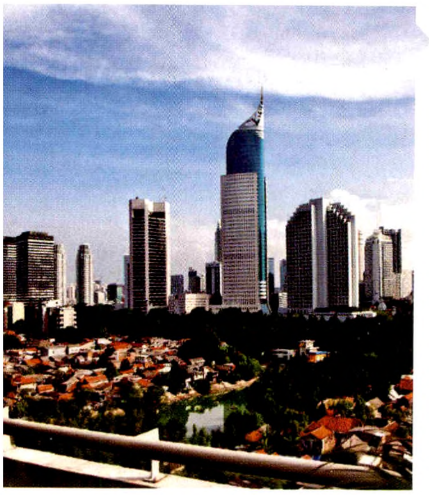
MNRE AND MOP&NG SIGN MOU FOR ENERGY SECURITY

Secretaries of the Ministry of New and Renewable Energy (MNRE) and the Ministry of Petroleum and Natural Gas (MOP&NG) Mr Vivek Rae and Dr Satish Agnihotri, signed an MOU in the presence of Dr Veerappa Moily, Minister (MOPNG and MOEF), and Dr Farooq Abdullah, Minister of New and Renewable Energy.

The aim of the MOU is to enhance energy security along with clean energy development through investments in solar, wind, and other renewable energy projects. Two Special Purpose Vehicles (SPVs) are proposed to be set up for promoting the deployment of technologies to supplement conventional fossil fuel based power generation that will give boost to the development of large-scale grid connected renewable energy projects and implementing off-grid applications. The first SPV is for installation of large-scale grid connected power generation plants based on renewable energy. ONGC will be the lead partner in this SPV, along with equity participation from Oil India Limited (OIL), GAIL (India) Limited, and Engineers India Limited (EIL) and also the PSUs under MNRE viz., Solar Energy Corporation of India (SECI) and Indian Renewable Energy Development Agency (IREDA). The second SPV is for setting up renewable energy off-grid projects using advanced technologies and market-based business solutions for promoting access to the energy deficient population. Indian Oil Corporation will be the lead partner in the second SPV, along with equity from BPCL and HPCL and also represented by SECI and IREDA.

EIL has been assigned the task of preparing the Feasibility Report for assessment of overall economics of the projects, development of business models based on expected returns, risk analysis, etc., for the two SPVs. The Feasibility Reports will be prepared within three months and the two SPVs will be incorporated immediately thereafter, based on the Feasibility reports. Implementation of the MOUs will be monitored by a Steering Committee under the Chairmanship of the Secretary, Ministry of Petroleum and Natural Gas with Secretary, MNRE as Co-Chairman.

Source: http://freepressjournal.in



INDONESIA PLEDGES $250,000 TO GREEN CLIMATE FUND

Indonesia has pledged US$ 250,000 to the Green Climate Fund, a move they hope will spark further contributions from other countries. A meeting in Bali seeks to lay the groundwork so that the GCF can become fully operational. Indonesia's Deputy Minister of Finance, Bambang Brodjonegoro, made the announcement at a reception hosted by the Government of Indonesia. His pledge means that Indonesia has become the second developing country to contribute money to the GCF, after South Korea pledged $40 million last year to help with work establishing exactly how the Fund will function. The GCF was set up by the UN in 2010 as a channel for the money that governments will contribute towards tackling climate change. Developed countries have promised to donate $100 billion every year beginning from 2020. Developing countries have no formal obligation to provide funds, which makes Indonesia's pledge particularly significant.

A number of developed countries have also made contributions, including Germany, Denmark, Norway, Australia, Finland, and the Netherlands. "I think it's a really laudable gesture, demonstrating that some developing countries are really committed to making the GCF work," said Smita Nakhooda, a Research Fellow at the Overseas Development Institute, who is attending the talks in Bali. "It's been a difficult set of talks, but this inserts some much needed positivity I think." It is not clear yet whether this money will go towards setting up the Fund itself, or go directly towards funding climate change projects. A spokesperson at the UK's Department for International Development (DFID) said the government would wait until the latest round of talks conclude before deciding on their own contribution. "We will make an assessment of the value for money of the GCF relative to alternatives and its potential to achieve its objectives once the main design elements have been agreed," they said.

Source: http://www.theclimatecoalition.org

CALIFORNIA SENATORS FLOAT POST-2020 CLIMATE CHANGE BILL

Two California state senators released a Bill that would give regulators the authority to design a plan to meet the state's long-term greenhouse gas reduction goals and improve air quality in the state's poorest communities. The Bill is an effort by Democratic senators Fran Pavley and Ricardo Lara to get the legislature's blessing for an extension of the state's pioneering climate change efforts beyond the end of the decade.

But it would leave details of how to achieve the state's goals to the California Air Resources Board, which is already working on a post-2020 climate change plan. "This Bill looks to the future, sending a clear signal that California intends to continue its climate leadership," Pavley said.

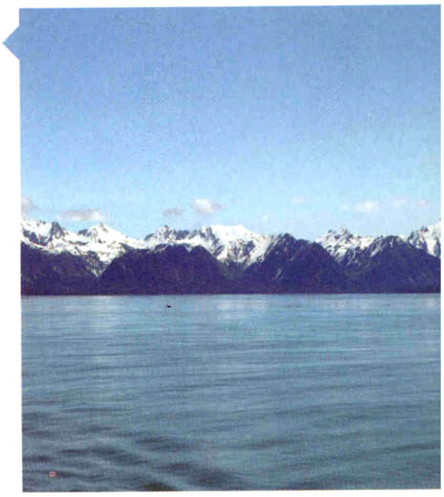
The Bill brings together Pavley, the author of the state's landmark 2006 Bill that set its 2020 and 2050 targets, and Lara, who in the past has been critical of components of the state's cap and trade program, a key state policy.

The Bill reflects Lara's long running concern for residents in the state's most disadvantaged communities, where air quality tends to be worse. It emphasizes the need for the state to cut not only carbon emissions, but also its output of pollutants such as black carbon and methane, which not only impact global warming but also have put the San Joaquin Valley, Los Angeles, San Diego and Sacramento out of compliance with the Clean Air Act.

"We must ensure that all communities, including disadvantaged communities throughout California, have the promise of a clean environment today and into the future," Lara said.

Source: http://www.reuters.com

FERC GRANTS NEW PERMIT FOR 240-MW ALASKA TIDAL ENERGY PROJECT



The Federal Energy Regulatory Commission has approved a successive preliminary permit for Turnagain Arm Tidal Energy Corporation for a tidal energy project in Alaska. In February 2013, Turnagain Arm Tidal Energy filed an application proposing to continue to study the feasibility of the Turnagain Arm Tidal Electric Generation Project. The project would be located on the Turnagain Arm of Cook Inlet and adjacent lands of the Kenai Peninsula Borough and the Municipality of Anchorage, Alaska.

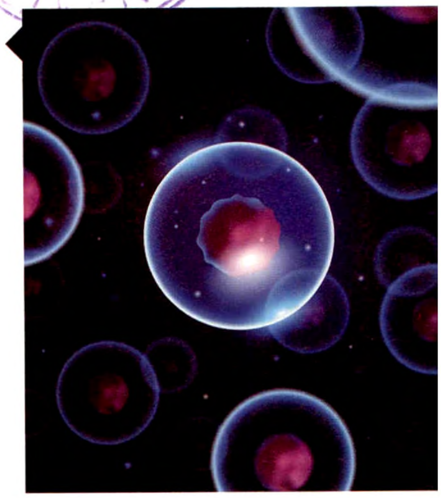
The proposed project would consist of an 8-mile-long tidal fence situated between Fire Island in the Municipality of Anchorage and Point Possession in the Kenai Peninsula Borough consisting of 24, 10-MW low-head, bi-directional horizontal bulb turbines for a total installed capacity of 240 MW; a 2-mile-long and 1-mile-wide water storage tank attached to the tidal fence; one control building/substation onshore near Anchorage and one near Point Possession; an 18-mile-long, 230-kV submerged transmission line connecting the tidal fence to the existing Chugach Electric Association substation at Point Woronzof in Anchorage and a new substation at Point Possession; and a 28-mile-long, 230-kV above-ground transmission line running parallel to an existing Homer Electric Association transmission line corridor and extending from Point Possession to the existing HEA Nikiski substation.

The proposed project would have an estimated average annual generation of 1,271,950 megawatt-hours.

Source: http://www.renewableenergyworld.com

CALCUTTA UNIVERSITY
CENTRAL LIBRARY

EUREKA! LIVING CELLS CREATED IN LAB



Inspired by natural materials such as bone, minerals, and other substances, engineers have coaxed bacterial cells to produce biofilms that can incorporate non-living materials such as gold nanoparticles, and quantum dots.

These 'living materials' combine the advantages of live cells which respond to their environment, produce complex biological molecules and span multiple length scales, with the benefits of nonliving materials that add functions such as conducting electricity or emitting light.

"The new technique could one day be used to design more complex devices such as solar cells, self-healing materials or diagnostic sensors," said Timothy Lu, Assistant Professor of electrical engineering and biological engineering at Massachusetts Institute of Technology (MIT).

The idea is to put the living and the nonliving worlds together to make hybrid materials that have living cells in them and are functional, Lu added. "It is a simple system but what happens over time is you get curli that is increasingly labelled by gold particles. It shows that indeed you can make cells that talk to each other and they can change the composition of the material over time," Lu explained.

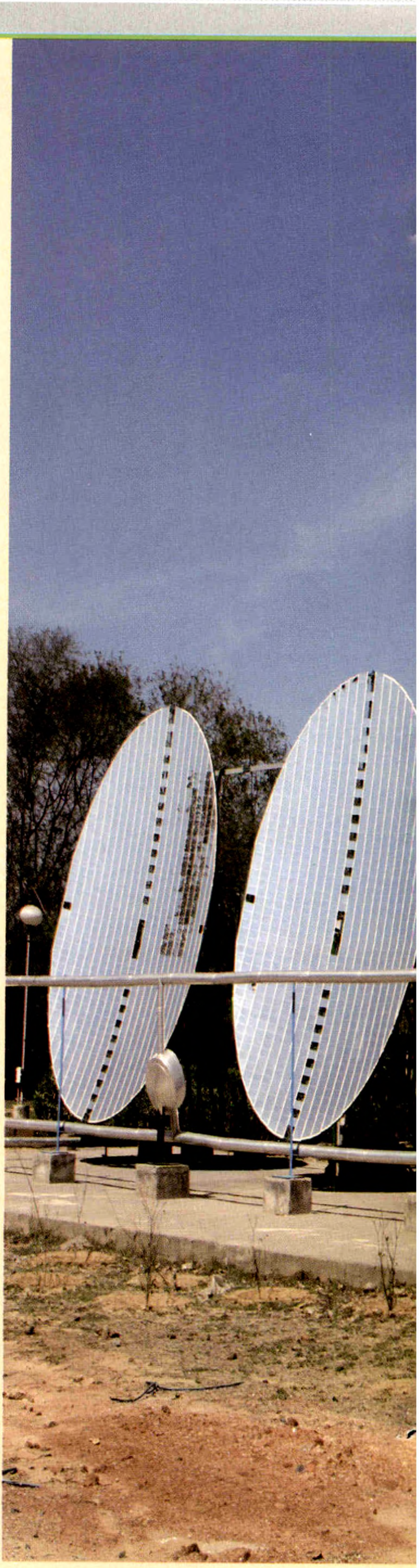
Lu and his colleagues chose to work with the bacterium E. coli because it naturally produces biofilms that contain so-called 'curli fibres' — amyloid proteins that help E coli attach to surfaces. Each curli fibre is made from a repeating chain of identical protein subunits called CsgA which can be modified by adding protein fragments called peptides. These peptides can capture nonliving materials such as gold nanoparticles, incorporating them into the biofilms. They also engineered the cells so they could communicate with each other and change the composition of the biofilm over time.

These hybrid materials could be worth exploring for use in energy applications such as batteries and solar cells, said the researchers in the journal *Nature Materials*.

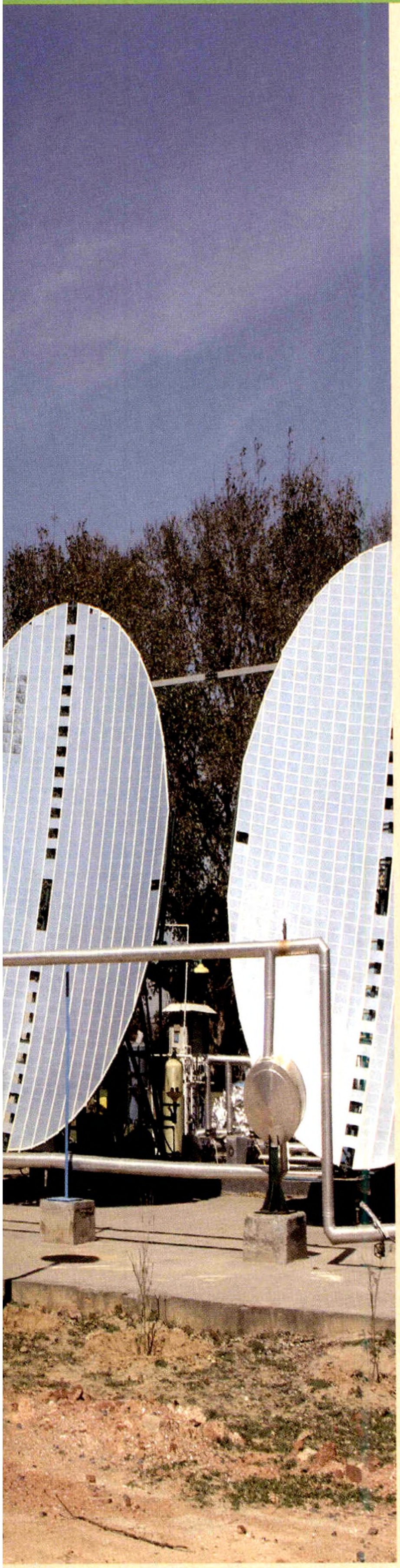
Source: http://www.newstrackindia.com

ARRIVED COLD STORAGE SOLUTION FOR VILLAGES

Post-harvest wastage of food produce has been a major impediment to ensuring food security in India. Lack of electrified villages without adequate cold storage facilities, is only aggravating the problem. **Ankit Narula** and **Lovedeep Mann** report on a ground-breaking method of running cold storage in non-electrified villages using energy from the sun and a biomass-based gasifier, developed by the National Institute of Solar Energy (NISE), TERI, and Thermax Ltd.



In what can be termed as a major advancement in the way post-harvest produce is handled, The Energy and Resources Institute (TERI) has developed a method in which cold storages can now be installed at the farm gate level in villages, unlike the conventional supply chain where they appear much later, usually near markets or big towns. One of the major impediments which TERI has managed to address is the running of the cold storage unit. This innovation is self-sustainable and can be used for village applications or in locations which do not have access to electricity or where electricity supply is unpredictable and erratic.



For a long time, electrification has been an important agenda item in the debates around rural development, and the subject of using cleaner fuel for lighting has been occupying the centrestage. Renewable energy has played a very significant role in providing an alternative to the extension of grid infrastructure; for instance, the application of solar photovoltaic for electricity supply. Renewable energy also has a potential beyond electricity supply where applications based on renewable energy can be integrated to the daily chores of rural population, although this aspect has been given little attention in low-and middle-income economies such as such as India, where the grass roots populations are the rural poor whose lives orbit around farming, animal husbandry, irrigation, and managing harvest. Therefore, in order to bring a real change in the lives of rural people it is important to focus on activities in their daily lives. And in that setting, agriculture is the most important activity, where renewable energy applications can make a large impact.

THE CONTEXT: CALL FOR ENHANCING AGRICULTURAL PRODUCTIVITY

India is an agriculture-based economy and a lot of people depend on it. Around 70 per cent of the people are involved across its value chain starting from harvesting, procurement, marketing, transportation, fertilizers, and so on. The World Bank too recognizes the importance of India's food security which majorly depends on producing cereal crops, as well as increasing production of fruits, vegetables and milk, to meet the demands of a growing population.[1]

> " IN THIS PARTICULAR INNOVATIVE SOLUTION, THE COLD STORAGE IS RUN CHIEFLY ON THE THERMAL CYCLE – TYPICALLY USED IN OUTSIZED COLD STORAGES OR AIR-CONDITIONING SYSTEMS – INSTEAD OF ELECTRICITY.

The current production capacity of fruits and vegetables in India is approximately 60 million tonnes per annum, putting India at the second spot in world rankings. Taking horticulture as a whole, the contribution of agriculture to India's GDP is approximately 6.5 per cent. However, when considering the efficiency of delivery and supply of this massive magnitude of produce, India lies at the bottom-most rung. Wastages are colossal.

A report by the Planning Commission of India articulates the reason behind post-harvest losses, especially in Uttar Pradesh (UP) and Bihar, and points out that the absence of sufficient cold storages in the country is a major reason. Most of the cold storages in the country are typically located in cities or near the market places, and fewer near the farms, which shows a critical limitation in the overall supply chain. In fact there have been other researches that confirm the same, such as one conducted by Emerson estimating the quantum of wastages at INR 133 billion (or Rs 13,300 crore) per year.

Greater the distance or time spent between harvesting and its arrival in the market, greater is the risk of deterioration of produce. The cold storages near the farm gate or in villages can fundamentally serve as the store room for stockpiling excess

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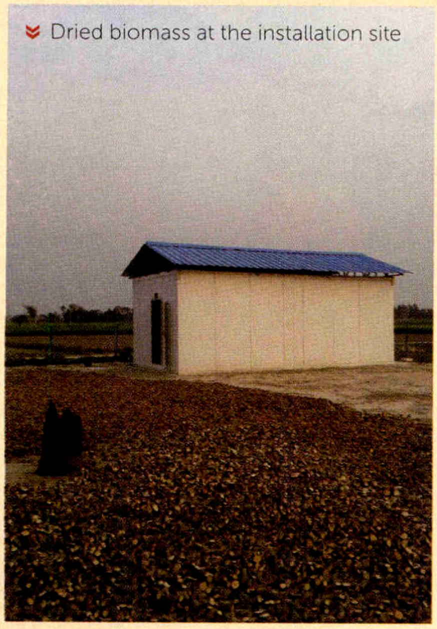
[1] http://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities



Dried biomass at the installation site

produce which the farmer does not wish to sell immediately, especially during times the market has sufficient or excess supply (linked to perhaps the season for a produce, say potato) and prices take a nose-dive. Besides, saving a large magnitude of harvest, this may give farmers a chance to earn extended profit. In addition, the farmers could also save their produce so as to be able to trade in their local market, which may not be possible for them otherwise due to unavailability of conditioned space for sustaining the harvest longer or for another day or two. This will also reduce the dependence on transportation or reefers, and thereby reduce additional expenditures.

A GROUND-BREAKING METHOD FOR RUNNING COLD STORAGES AT THE FARM LEVEL

Electricity is the most critical of inputs for establishment of a cold storage and its operation. The chief reason for the absence of cold storages near farms is the unavailability of electricity in villages, besides the manner in which business is conducted around cold storages. Although India boasts of 95 per cent electrification in villages, only around 55 per cent of households in rural India are electrified, and the ones which are fortunate enough to be electrified receive electricity for only few hours a day (around six hours a day during off-peak period), and that too with critical uncertainty. In a conventional cold storage, the energy expenses account for approximately 28 per cent of costs which also shows the importance of it in daily operation of the cold storages.

The reason that not many private or government enterprises have entered the cold storage market or installed cold storages near farm gates or in villages is because they do not see much business sense in it. This is mainly due to the absence of grid electricity. The only alternate way therefore to run the cold storages is by means of diesel engines, which can prove to be extremely uneconomical, especially when preserving a lower quantum of produce, (covering a village or few at most).

The development work is being carried out with support from the Ministry of New and Renewable Energy (MNRE), Government of India, in association with TERI under the sponsorship of the Asia Pacific Partnership on Clean Development and Climate and in partnership with the National Institute of Solar Energy (NISE), MNRE; Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia; and Thermax Ltd., India. In this particular innovative solution, the cold storage is run chiefly on the thermal cycle — typically used in outsized cold storages or air conditioning systems — instead of electricity.

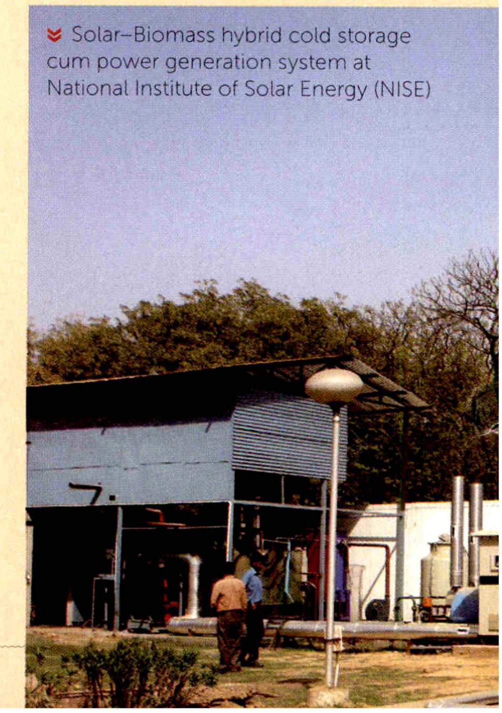
Together with the system design, a scoping study was carried out to understand the status of cold storage requirement across pan India, with a special focus on UP, Punjab, and Bihar. In this study various aspects were included: state-wise production quantum of fruits and vegetables, supply chain and the role of various actors in it, wastages, availability of cold storage facilities, storage and operational method used in conventional large-scale cold storage, status and demand of cold storages in rural areas, etc. This has greatly helped in forming the base of this project and rationalizing its requirement.

THE SYSTEM CONFIGURATION

With the background that India is blessed with perennial supply of biomass and solar energy resources, National Institute of Solar Energy (NISE) – TERI – Thermax developed this biomass/biomass–solar hybrid system. The system can provide cold storage facility for storing about 25 tonnes of fruits and vegetables, besides supplying clean power for village electrification. The cold storage facility is capable of achieving temperatures as low as 0 °C, which gives an opportunity to keep a wide variety of fruits, vegetables, and horticulture produce in it. The system also provides 50 kW of electrical power at grid quality which can be supplied for running domestic, community, commercial, as well as other productive loads in a typical village.

Solar thermal system

Due to abundant and high-quality of solar energy resources spread across the country, it is possible to utilize



Solar–Biomass hybrid cold storage cum power generation system at National Institute of Solar Energy (NISE)

Vapor Absorption Machine (VAM) and cold storage

them for applications at far-flung villages. In the current system which is a pilot project set-up at the SEC, Gurgaon, the solar system consists of four Scheffler dishes designed to supply hot water. These Scheffler dishes offer a unique advantage with fixed or stationary focus over other reflectors/concentrators which are built and installed along the east-west direction. The Scheffler dish system is a tested and proven technology to generate steam/high temperature water. Other applications of Scheffler dishes which have been tested and installed at numerous locations in India and abroad also include food processing.

Besides solar concentrator, the plant consists of a circular receiver, header, automatic tracking system, valves, and controls. A battery of receivers is connected to the hot water supply and return headers. The solar thermal system is integrated with other sources of heat in such a manner that utilization of solar thermal energy is maximized. The solar concentrator concentrates the sun light and generates high temperature pressurized water (130–140 °C) at the solar receivers in some time after the starting of the system. Circulation pump remains in operation to circulate hot water to the solar receivers during this time. Once the temperature is reached, hot water is used for further operation in a special refrigeration system, also called as Vapour Absorption Machine, or simply VAM. There is a backup heating system which is operated or used, in case solar energy cannot maintain the required temperature. The working of the system can be seen in Figure 1.

Biomass gasifier

In order to complement the solar concentrator scheme, a biomass-based gasifier has also been integrated into the system. This gasifier generates syngas by converting wood pieces through a thermo-chemical process. The syngas is then fired in a modified Internal Combustion engine which is capable of generating 50 kW of power. The heat from the exhaust of gasifier engine is captured and supplied to the VAM for its operation. This arrangement has been kept because of two reasons. First, in case heat available from solar field is less or absent because of no sun in the

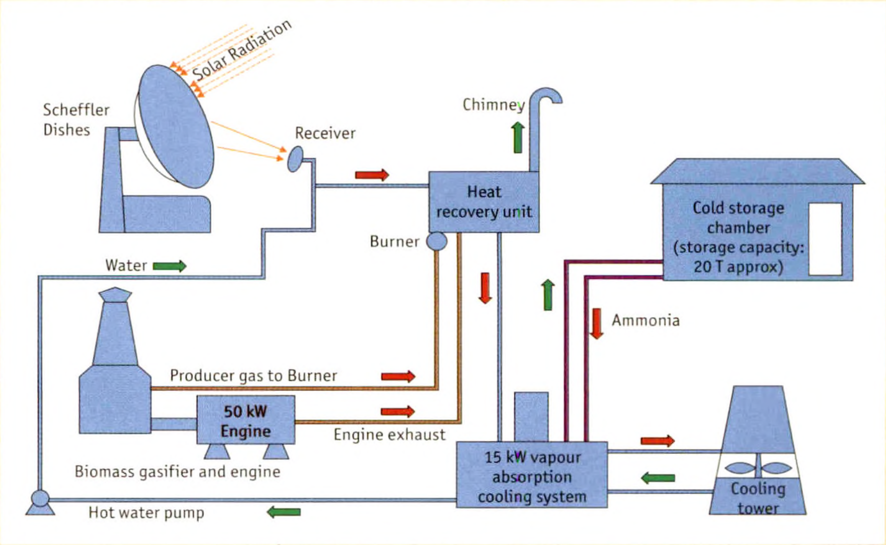


Figure 1: Working System of the Cold Storage

sky, the heat from alternate loop, i.e. gasifier engine can be utilized to run VAM. The second reason is that this configuration is also used for supplying electricity to the village.

Vapour Absorption Machine

Vapour Absorption Machine (VAM) used in this system is based on ammonia–water configuration. VAM of 15 kW — which translates to a cooling capacity of around 4.27 TR (tonnes of refrigeration) — is the first of its kind developed for low-end applications. This initial prototype was developed and supplied by Thermax Limited. This system which TERI's research shows is less effective than the conventional vapour compression system or conventional refrigeration system, but offers a remarkable option to use waste heat recovery and its coupling with solar energy. However, there are ways to increase the efficiency of the system while adjusting and judiciously using the temperature of cooling water.

> COLD STORAGES PRESENTLY OPERATING ARE MOSTLY LARGE-SIZED AND BUSINESS-ORIENTED. WHEREAS, DECENTRALIZED, SMALL COLD STORAGES OR SYSTEMS AT THE FARM GATE LEVEL WHICH CAN BE RUN BY THE VILLAGE COMMUNITY IS A VERY NEW CONCEPT.

Cold room

The cold storage cabinet used in this project was prefabricated, whereas its design was selected after analysing various parameters like the heat load in the cold storage, cold room transmission load through the walls, air cooling, air change load through leakages, auxiliary load, etc. The total electrical requirement for running the cold storage which included loads such as VAM pumps, hot water pump, solar tracker, etc., is 10.45 kW. The balance power available for supplying electricity to the rural areas out of 50 kW is 39.55 kW.

The capacity of engine, gasifier, the size and number of dishes, and size of the cold storage was decided keeping in mind the available resources, i.e., both solar energy and biomass, and the typical need of a village. Currently, the electricity from the engine is supplied to the Solar Energy Centre.

REAL TIME BIOMASS-BASED COLD STORAGE AND VILLAGE ELECTRIFICATION

In the subsequent activities, TERI and CSIRO with the support from Australian Agency for International Development (AusAID) has undertaken what can be called as the second phase of TERI's initiative, a collaborative research which is aimed at developing and testing a business model for providing both electricity and small-scale cold storage in a village setting.

The cold storages presently operating is mostly large-sized, oriented towards business and focused on profits, whereas, decentralized, small cold storages or systems at the farm gate level which can be run by the village community is a very new concept. The only way to test the practicality of such an idea is to have it on the field and test it in the real rural conditions. Hence, TERI took it forward and installed the same configuration minus solar field in a village in UP.

The village chosen for this research project is based on many criteria: being an un-electrified village, community interest, cold storage requirement — to name a few. The cold storage which is central to the project can be chilled to 0°C. The project is run by a "Village Energy Committee" or better known as VEC

> TERI AND CSIRO WITH SUPPORT FROM AUSAID HAS UNDERTAKEN COLLABORATIVE RESEARCH AIMED AT DEVELOPING AND TESTING A BUSINESS MODEL FOR PROVIDING ELECTRICITY AND SMALL-SCALE COLD STORAGE IN A VILLAGE SETTING.

which owns, regulates, maintains, and oversees the operation of the system, besides deciding the charges of electricity and for using cold storage. The committee consists of eight members and has representatives from the village panchayat, village community, and a local NGO. Care has been taken to have fair representation of women, with three female members being elected to the village committee. Regular training is given to the VEC in order to increases awareness such that they can be involved in the operation of the system.

The electricity generation system is similar to the preceding project and used for supplying electricity firstly to run the cold storage and other miscellaneous loads in the plant and then supplying the rest quality controlled electricity — at 50 Hz frequency and 3-phase supply — to 140 households spread over two villages — Bankipur and Rehaspur, around 70 kms away from the capital of Uttar Pradesh, Lucknow — with every household eligible to use 150 W of electrical load, that can be expanded or changed based on an individual user's need or community requirement. The distribution system is installed to supply electricity in both the villages conforms to all technical specifications and safety features as per REC standards. LED, based streetlights are installed with dimming and movement actuated features in order to save electricity.

teri
BIOMASS ENERGY BASED 50 kW, VILLAGE ELECTRIFICATI
AND COLD STORAGE PROJECT
SUPPORTED BY THE AUSTRALIAN AGENCY FOR INTERNATIONAL DEVELOPMEN
DESIGNED AND EXECUTED BY THE ENERGY & RESOURCES INSTITUTE
IN COLLABORATION WITH
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (AUSTR
AND
PARTICIPATORY ACTION FOR COMMUNITY EMPOWERMENT
DEDICATED TO THE NATION ON 28th NOVEMBER 2013 BY
DR. FAROOQ ABDULLAH
HON'BLE MINISTER OF NEW & RENEWABLE ENERGY
GOVERNMENT OF INDIA

System inauguration by Hon. Dr Farooq Abdullah, Minister, MNRE

The plant was inaugurated on 28 November 2013 by Dr Farooq Abdullah, Honorable Minister, Ministry of New and Renewable Energy (MNRE) in the presence of Dr R K Pachauri, Director-General, The Energy and Resources Institute (TERI), and other dignitaries.

OVERALL BENEFITS OF THE TWO PROJECTS

With the overall objective of finding new and innovative ways to introduce small cold storages for village application in the existing supply chain, which can be operated under limited resources, TERI has managed to test two most critical aspects, i.e., technology and suitable business model. These interventions can lead to significant development in rural areas by providing both electricity and cold storage facility which has visible impacts on overall socio-economic development in rural areas. Other benefits include introducing entrepreneurial wisdom, providing an alternative to burning kerosene for lighting, and most importantly in improving the quality of life of the villagers. Besides, with this, the community of Bankipur and Rehaspur has become innovative and have now come up with new ideas and requirements around cold storage and electrification system, which signal progress in the villages.

> THE DISTRIBUTION SYSTEM IS INSTALLED TO SUPPLY ELECTRICITY IN BOTH THE VILLAGES CONFORMS TO ALL TECHNICAL SPECIFICATIONS AND SAFETY FEATURES AS PER REC STANDARDS. LED-BASED STREETLIGHTS ARE INSTALLED WITH DIMMING AND MOVEMENT ACTUATED FEATURES IN ORDER TO SAVE ELECTRICITY.

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REMOTE SENSING APPLICATION IN WIND ENERGY

A growing number of wind turbines are being installed at challenging mountainous and offshore sites today. **Siraj Ahmed** explores the use of Remote Sensing technologies such as SODAR and LIDAR that have replaced the erection and installation of high met masts.

INTRODUCTION

In recent times, wind turbines are being frequently installed in hilly, forested, and complex mountainous terrains as well as at offshore sites with ever increasing hub heights. The conventional method of accredited wind resource assessment is to mount cup-anemometers and direction sensors on a tall meteorological (met) mast. It has been seen that because of the increasing hub height of modern wind turbines, the cost of met towers are also increasing, approximately to the third power of height. In such cases, getting licencing permission for the installation of a high met mast is very time consuming. The measurement of wind speed at 100 m height for a modern 5 MW wind turbine hub level at a single point by cup-anemometer is no longer a representative speed of wind for a rotor diameter spanning more than 120 m. The rotor blade tip from lower most point to upper most point for such a wind turbine will be at a height from 50 m to 200 m. Cup-anemometer is a point measurement device, whereas using a SODAR or LIDAR at 100 m height probes a sampling volume in order of 1,000 m^3.

Remote Sensing application in wind energy is used to supplement as well as replace tall met mast measurement for the following purposes:

- Wind resource assessment whereby global wind resources are mapped onshore, at plains, over hilly and mountainous terrains, in coastal areas, offshore, etc.
- Evaluation of various wind flow models and development of wind atlases of micro, macro, and global scales
- Power performance verification of wind turbines
- Wind turbine online and forward-feed controls

The IEC 61400-12-1 standard for power curve measurement specifies that a calibrated cup-anemometer at hub height and two to four rotor diameter up-wind in front of wind turbine is to be mounted. With this arrangement the wind speed measurement is based only at a single point measurement. For a modern wind turbine of rotor diameter spanning 120 m, the wind field over the entire plane cannot be represented by a single point measurement, that too especially in mountainous and complex terrains. Wind turbines operate in an atmospheric boundary layer which has high turbulence levels due to the wind shear caused by roughness of the earth surface. To characterize the wind flow over the entire rotor plane, multi-point and multi-height wind measurement will be required. Remote Sensing application is now available commercially to fulfil these requirements. Remote Sensing techniques based on sound and light waves propagation and back scatter detection such as Sound Detection and Ranging (SODAR), Light Detection and Ranging (LIDAR), satellite-based sea surface micro-wave scatterometry, and Synthetic Aperture Radar (SAR) are useful replacements of expensive met mast based sensors. These techniques also replace the time consuming erection and installation of a high met mast. SODAR and LIDAR are direct measurements of wind speed based on Doppler Shift, while SAR is based on proxy-empirical calibration methods.

> REMOTE SENSING TECHNIQUES BASED ON SOUND AND LIGHT WAVES PROPAGATION AND BACK SCATTER DETECTION SUCH AS SODAR, LIDAR, SATELLITE-BASED SEA SURFACE MICRO-WAVE SCATTEROMETRY, AND SYNTHETIC APERTURE RADAR (SAR) ARE AN USEFUL REPLACEMENT OF EXPENSIVE MET MAST BASED SENSORS.

SODAR

SODAR are developed and based on an audio-frequency technology. Under the SODAR technique, a ground-based instrument transmits a sequence of short bursts of sound waves of audible range frequencies from 2,000 to 4,000 Hz aloft at various heights in the atmosphere in three directions. A small fraction of transmitted sound wave propagation is scattered and reflected in all directions from the temperature differences and turbulence in the atmosphere. A very small fraction of scattered waves is received back into the receiver or detector of the SODAR instrument. The height at which the wind speed is measured, will be determined by the delay in time in the back scatter of the transmitted pulse. Under standard atmospheric conditions, the speed of sound propagation is about 340 m/s. For example, the back scatter of sound waves from a height of 170 m above the ground will be received back into the detector after delay of one second. The wind speed is determined as a function of the Doppler Shift observed from the frequency difference between the transmitted sound wave or light beam and frequency of back scatter received by the SODAR or LIDAR instrument.

SODAR are typically applicable for measuring 10 minute averaged vertical profile from 20 m to 200 m height aloft for following parameters — mean wind speed, mean wind direction, and turbulence in three directions. It can be used for direct control of the wind turbine by installing it in the spinner of the hub. It can also work as gust warning system and for power optimization.

There are two types of SODAR systems available — mono-static and bi-static. In the mono-static system, transmitter and receiver are co-located on the ground. In the bi-static system, the transmitter and receiver are separated at about 100 to 200 m apart on the ground. The carrier to noise ratio (C/N) is higher for the bi-static system as compared to the mono-static system. The bi-static Continuous Wave (CW) SODAR system is preferred due to higher accuracy considered for wind energy applications. In a number of applications, it is seen that the mean wind speed and direction measurement by SODAR is within the accuracy of ± 3 per cent as compared to a cup-anemometer. It is to be noted that 1 per cent uncertainty in mean wind speed results in 3 per cent uncertainty in mean wind power. SODAR is a relatively cheaper option when compared to LIDAR with low power consumption of about 10 W per unit. Some of the manufacturers of SODAR systems are Remtech, Atmospheric System Corporation, Metek, Scientec, Second Wind, AQ System, etc.

SODAR Triton

LIDAR

LIDAR

LIDAR is a remote sensing application of wind parameters such as speed, direction, and turbulence by using laser light. A LIDAR is used to measure wind speed and direction by probing the wind flow in the atmosphere from a ground-based instrument using laser beams. The wind measurement is achieved by detecting the Doppler Shift in the back scattered light. The Doppler Shift is directly proportional to wind speed in the direction of laser beam in the adjustable measurement volume in the atmosphere. LIDAR can be used at various ranges and angles, and at different heights. In the LIDAR system, electromagnetic radiation of light in the form of laser of wavelength of about 1.5 μm near infra-red is transmitted in the atmosphere at the point of interest. The back scattering of light from many small aerosols suspended and moving with the wind will be detected by a receiver of LIDAR in the form of small frequency shifts or Doppler Shifts. Wind LIDARs work on two measurement principles, i.e., Continuous Wave (CW) LIDAR and pulsed LIDAR.

Continuous Wave (CW) LIDAR

In this application, a continuous laser beam is transmitted aloft in the atmosphere from a LIDAR system and back scattering is received continuously at the receiver to record Doppler Shift at a particular height. It focuses beams at different heights for measuring wind speeds. The measurement heights or range of measurement and spatial resolution of a continuous wave LIDAR is controlled by focal properties of the telescope. It works like a photographic camera to control the aperture, more for shorter distances and lesser for longer distances.

Pulsed LIDAR

It transmits a sequence of short pulses of laser beam in the order of 30 m wave lengths and detects back scattered light. The measurement of wind speed in the direction of beam is related to Doppler Shift.

Comparatively, CW LIDAR showed higher spatial resolution and faster data acquisition than pulsed LIDAR and therefore the former is preferred for turbulence measurements. Pulsed LIDAR is preferred for wind speed measurements at multiple heights, simultaneously with higher ranges.

Wind Profiler

A wind profiler measures average parameters of vertical wind speed profiles, vertical direction profiles, vertical turbulence profiles through a series of radial direction measurement of several components of wind speed normally based on 10 minute data sampling, aloft in the atmosphere in beam direction. It is a ground-based system transmitting a continuous or pulsed laser beam. It works on the same principle of

> UNDER THE SODAR TECHNIQUE, A GROUND-BASED INSTRUMENT TRANSMITS A SEQUENCE OF SHORT BURSTS OF SOUND WAVES OF AUDIBLE RANGE FREQUENCIES FROM 2,000 TO 4,000 HZ ALOFT AT VARIOUS HEIGHTS IN THE ATMOSPHERE IN THREE DIRECTIONS.

Doppler Shift detection in back scattered radiation. A wind profiler has a transmitter and receiving antennas, and both are combined in a single optical telescope.

The LIDAR system of measurement shows higher accuracy due to following features:

- Nature of light which is 10^6 times faster than a sound wave.
- Antenna aperture size of LIDAR is based on the wave length of light. The ratio of its lens diameter to wave length is more than 1,000 which results in better beam control and higher data sampling rate.
- Both types of LIDARs — continuous and pulsed wave — are based on the assumption that measured wind speed is proportional to Doppler Shift and also that aerosols are homogenously distributed and follow mean wind flow.
- LIDARs can be mounted on hub at the spinner or in the blades. The LIDAR can see the wind front 300 m to 400 m ahead of wind turbine and by the time the wind strikes the blades, it can activate the pitch of the blade for appropriate angle of attack ensuring optimum aerodynamic performance. It works on active control of blade pitch and nacelle yaw movement as a forward-feed control strategy. It also reduces the fatigue damage from extreme wind speeds and wind shear due to the forward-feed control which results in prolonging the life of the wind turbine. There is improved power performance as a result of enhanced yaw control and lead-time control of blade pitching for approaching wind front.
- The LIDAR system is based on volume-averaged wind measurement and therefore is more representative than the point-based cup-anemometer.
- Wind LIDARs are mobile instruments as compared to fixed location met mast mounted cup-anemometers and better suited for onshore as well as offshore applications.

Some of the manufacturers of LIDAR systems are Natural Powers (ZephIR), OPDI Technologies and DTU Fotonik (WINDAR), Coherent Technologies Inc. (Wind Tracer), Leosphere (WindCube), Catch the Wind Inc. (Vindicator), Sgurr Energy (Galion), etc.

SCATTEROMETRY

Scatterometry is a technique used for Remote Sensing wind characteristics such as speed, direction, and turbulence aloft the sea surface. Scatterometers are active radards that send pulses towards the surface of sea and measure the back scattered signal due to small-scale waves in the order of 20 mm. Post processing of back scattered signals relate to wind speed. SAR is based on a similar working principle and measures the back scattered signals related to wind speed. Sun synchronous satellite over the ocean fitted with radar scatterometers operating at different sub-bands of micro-wave are widely used to measure near-surface wind speed and direction. Radars operate at different sub-bands with in the micro-wave range of electromagnetic radiation spectrum. As per IEEE standard (2002) Radar Band Spectrum, given in Table 1, scatterometers are typically based on C and Ku sub bands. The Indian Space Research Organisation (ISRO) launched satellite Oceansat-2 in 2009 with a Ku band scatterometer.

A microwave radar pulse is transmitted towards the ocean surface and the reflected signal is received and measured. Small-scale ripples generated on the surface of water by the flow of wind satisfy the wavelength requirement for Brag Scattering of the incident pulse.

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Wind Collector

> THE LIDAR SYSTEM IS BASED ON VOLUME-AVERAGED WIND MEASUREMENT AND THEREFORE IS MORE REPRESENTATIVE THAN THE POINT-BASED CUP-ANEMOMETER

TABLE 1: RADAR Band Spectrum

Designation	Frequency	Wavelength
C-band	4–8 GHz	75–37.5 mm
Ku-band	12–18 GHz	25–16.7 mm

UPGRADED BOTTLED BIOGAS

A GREEN AND LOW-COST FUEL FOR AUTOMOBILES IN INDIA

Upgrading and bottling of biogas, a renewable energy source, can help in both waste management and building a sustainable environment. **Virendra Kumar Vijay** writes about on-going research developments in the field.

Enhanced energy security and climate change mitigation are the main drivers for the transformation of the energy system from one based on fossil fuels to that on renewable sources. Biomass has to play a key role in this transformation to a low-carbon economy. Worldwide, biomass accounts for more than two-thirds of all renewable energy supplies. Among biomass sources, biogas is an interesting option with a large potential, offering many exciting possibilities to supplement existing fuels and thereby reducing our dependence on fossil fuels.

WHAT IS BIOGAS?

For the uninitiated, biogas is formed by the digestion of organic waste including manure, sewage sludge, municipal solid waste, biodegradable waste, and seedcake into usage energy in a digester or in a landfill site. Biogas composition and its contaminants are dependent on the type of feedstock used. Biogas production is basically an anaerobic digestion which is considered to be a sustainable bio-conversion technology as it produces biogas which is a renewable gaseous fuel; it also stabilizes and reduces the volume of waste.

Rapid industrialization and population increase has resulted in the generation of huge quantities of waste, both solid and liquid, in industrial sectors such as sugar, pulp and paper, food processing, sugar/starch, distilleries, dairies, tanneries, slaughterhouses, poultry farms, etc. Hence, there is a huge potential for the installation of medium (85–1,000 m^3/d) to large-size (>1,000 m^3/d) biogas plants in the country depending upon the availability of the feedstock.

Biogas typically consists of methane (50–70%), carbon dioxide (30–45%), traces of water vapour, and hydrogen sulfide (H_2S). The composition varies according to the feed material used. Biogas has a heating value of 20–24 MJ. The presence of methane renders it combustible while carbon dioxide, besides being non-combustible, restrains

Anaerobic Digestors (overhead view)

its compressibility thereby making it difficult to be stored in containers. Raw biogas has to be upgraded to natural gas quality in order to be used in vehicles that are designed to use natural gas. This means that carbon dioxide (CO_2), hydrogen sulphide (H_2S), ammonia, particles, and water — and sometimes other trace compounds — have to be removed so that it can be used in vehicles. This is because by itself, biogas has a methane content of more than 90 per cent by volume. This upgraded gas is generally referred to as Biomethane which is bottled at discharge pressure of 200 bar. This is termed as Compressed Biogas (CBG). Further, using a CNG dispensing cable and a nozzle to NZS standards, this CBG can be used for filling the gas into the vehicles. The new biogas standard BIS:16087(2013) has been developed by the Bureau of Indian Standards (BIS)for its utilization in vehicles (Table I).

TABLE 1: BIS Standards for Biogas Composition in India (16087:2013 Biogas Specification)

Sl. No.	Biogas Components	Percentage
1	CH_4, %, Min	90
2	Moisture, mg/m^3, Max	16
3	H_2S, mg/m^3, Max	30.63
4	$CO_2+N_2+O_2$, % Max (v/v)	10
5	CO_2, %, Max (v/v (when intended for filling in cylinders)	4
6	O_2, %, Max (v/v)	0.5

Source: Bureau of Indian Standards

FEEDSTOCK OF BIOGAS AND ITS PRODUCTION

There are around 300 distilleries throughout India which collectively have a potential of producing 1,200 million Nm^3 biogas along with and 2,000 tannery units capable of producing 787,500 Nm^3 of biogas. The increasing number of poultry farms can also add to biogas productivity, as with the current population of 649 million birds, another 2,173 million Nm^3 of biogas can be generated.

As per the *Report of Planning Commission on Development of Biofuels* published by the Government of India in 2013, an estimated area of 13.4 million hectares of marginal/wastelands that are suited to growing Jatropha and this can cater to large-scale plantings so as to meet the blending targets fixed by the Government of India. Non-edible seed cake produced after the extraction of biodiesel has higher potential to produce biogas as slurries of the dung have high water content (in excess of 90%) which leads to relatively low specific methanogenic capacities. Table 2 shows biogas production for different feedstock.

TABLE 2: Biogas Production According to Feedstock

Feedstock	Gas Yield (m^3/kg)	Methane (%)
Cattle dung	0.297	55
Pig	0.40	65
Poultry	0.45	70
Straw	0.341	51
Grass silage	0.576	52
Municipal solid waste	0.308	60
Jathropa curcas seedcake	0.640	66.5
Pongamia pinnata seedcake	0.738	62.5

Source: National Society for Clean Air for Environmental Protection (2006), *Biogas as a Road Transport Fuel: An Assessment of the Potential Role of Biogas as a Renewable Transport Fuel*, M Pöschl, S Ward, P Owende (2010), 'Evaluation of Energy Efficiency of Various Biogas Production and Utilization Pathways', *Appl Energy* 87: 3305–21.; AsamZaki-ul-Zaman, T G Poulsen, A Nizami, R Rafique, G Kiely, and J D Murphy, 'How Can We Improve Biomethane Production per Unit of Feedstock in Biogas Plants?' *Appl Energy* 88: 2013–18.

BOTTLING OF BIOGAS

Upgraded and bottled biogas is a renewable energy source which can help both in waste management and in building a clean and sustainable environment. This technology is an economically viable option for biogas produced at medium to large scales. The Ministry of New and Renewable Energy (MNRE) has developed a national master plan for waste-to-energy projects along with the National Biogas and Manure Management Programme and biogas fertilizer plants for biogas upgradation and bottling programme with assistance from UNDP/GEF. The Government of India is exploring anaerobic digestion potential from all sources — municipal solid waste, crop residue, sewage sludge, animal manure, industrial waste which includes distilleries, dairy plants, pulp and paper, poultry, slaughter houses, sugar industries excluding waste water treatment plant — for two significant reasons; one being rocketing fuel pricing and the other stringent environmental regulations. The total potential of biogas from all sources has been estimated to be 48,382 million m^3/year. This amount when upgraded — and when assumed that 50 per cent of total upgraded biogas contributes towards transport sector and 50 per cent for cooking sector — then according to the *Indian Petroleum and Natural Gas Statistics 2011–2012*, this much upgraded and bottled biogas can fulfill 43.4 per cent of total transport sector demand and similarly around 41.7 per cent of cooking sector needs.

A biogas bottling system (see Figure 4) typically consists of the following equipment:

- High pressure gas compression
- Storage for upgraded biogas
- Dispensing nozzle system

> THE TRAILER MOUNTED MOBILE BIOGAS UPGRADING AND BOTTLING UNIT CAN BE TAKEN UP BY ENTREPRENEURS IN RURAL AREAS WHO SELL CBG LOCALLY FOR TRACTORS AND TRANSPORT VEHICLES IN THESE AREAS.

INDIAN INSTITUTE OF TECHNOLOGY

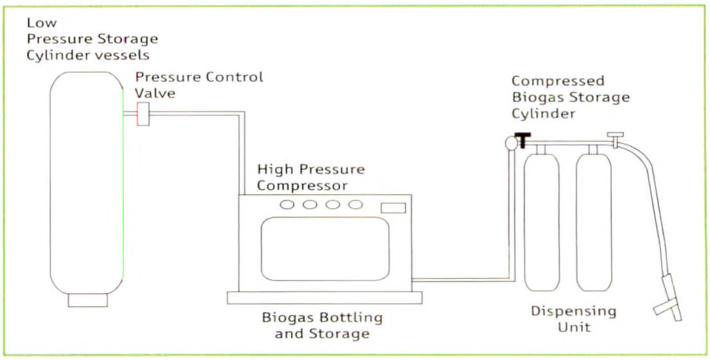
Low Pressure Storage Cylinder vessels
Pressure Control Valve
High Pressure Compressor
Compressed Biogas Storage Cylinder
Biogas Bottling and Storage
Dispensing Unit

Figure 4: Biogas Bottling System

Indian Institute of Technology, Delhi (IIT-D), has developed a small-scale biogas upgrading system using water scrubbing technology (20 m^3/h system). The water-scrubbing-based biogas upgradation and compression/bottling system is patented IIT-D for enhancing the utility of biogas application that is, in vehicles and cooking applications. The system consists of a water scrubbing column and a methane-enriched biogas compression system. The commercial viability of biogas purification and bottling

UTILIZATION OF BIOGAS FOR TRANSPORTATION

As per NGVA statistics in 2007:

- 12,000 vehicles were being fuelled with upgraded biogas worldwide, increasing to 70,000 biogas-fuelled vehicles by 2010
- In Europe, Sweden reports that more than half of the gas used in its 40,029 natural gas vehicles is biogas
- Germany and Austria have established targets of 20% biogas in natural gas vehicle fuel
- In the United States, biogas vehicle activities have been on a smaller scale

As shown in Table 3, the majority of natural gas vehicles are in the developing countries but in all of these countries NGVs are being run on natural gas due to the availability of the natural gas grid in most areas. In these countries, biogas production, upgrading and bottling is at an early stage and small scale, hence grid injection or bottling of upgraded biogas is non-existent.

However, few are aware that IIT Delhi has successfully launched India's first biogas-fuelled passenger car. Compressed biogas was tested on a regular CNG car for over 15,000 km. Good news is that environment emissions were seen to be lower than that in CNG. Also, existing CNG vehicles need not undergo any modification to be compatible to CBG.

BENEFITS

- Anaerobic digestion reduces the emission of green house gases into the atmosphere.
- It is a carbon neutral fuel.
- Dung management and sanitary toilets, attached to biogas digesters lead to better hygienic conditions
- The by-product of biogas technology, i.e., bio slurry is an excellent organic fertilizer which can be applied to farmers gardens
- Flexibility of feed stocks
- Closed system design for odour control
- It has lower emission levels than natural gas and diesel

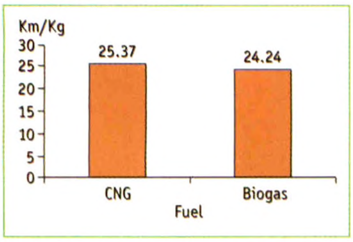

Figure 1: Fuel Consumption

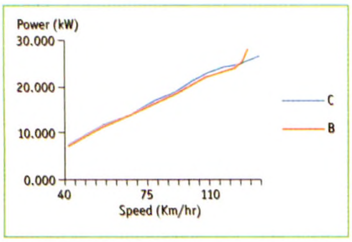

Figure 2: Power Curve

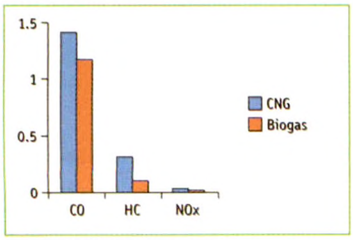

Figure 3: Emissions Chart

ICAT TEST RESULTS OF CAR ENGINE

FOR FUEL CONSUMPTIONS AND POWER GENERATION, THE ENGINE GIVES SIMILAR RESULTS FOR BIOGAS AND CNG, WHILE IN CASE OF EMISSION BIOGAS GIVES LESS EMISSION THAN CNG.

Biogas three-wheeler vehicle

plant can be attained above 500m^3/d capacity. Waste required for above capacity is around 20 tonne/d of cattle dung or 10 tonne/d of pig, poultry or food waste. This plant produces approximately 200 kg/d Compressed Biogas (CBG) and 3 tonne/d of semi-dried manure. Its payback period ranges from one year to four years depending upon the capacity of the plant, cost of raw material for gas production, and selling price of CBG. The system includes an anaerobic digester, biogas purification plant, high pressure compressor, and a cylinder storage cascade. Initial cost of the complete plant is approximately Rs 25 million excluding the cost of land for 1,000m^3/d. CBG can be used as a replacement of commercial LPG or vehicular fuel with typical selling cost of Rs 70/Kg. General selling price of manure is Rs 3–4/kg. At IIT-Delhi, regular CNG car has been tested on CBG for more than 15,000km. It was noted that existing CNG vehicles need not undergo any modifications to be compatible to CBG as a fuel. The fuel economy and mass emission of the vehicle fuelled with the Compressed Biogas (CBG) with 93 per cent CH_4 and CNG were evaluated. The emissions such as CO, HC, and NO_x are found to be marginally higher with the CNG than CBG with emission norms meet to the BS IV Norms. There is no significant change in millage of the vehicle fuelled with the CBG (24.11 km/kg) as compared to CNG (24.38 km/kg).

The Biogas Development and Training Centre, IIT-Delhi, is working to develop a mobile unit for biogas enrichment based on water scrubbing and pressurized swing adsorption system. This idea is for utilizing the left over biogas in small-sized biogas plants (<85 m^3/d) installed in villages for collection, upgradation, and bottling. The trailer mounted mobile biogas upgrading and bottling unit can be taken up by entrepreneurs in rural areas who sell CBG locally for tractors and transport vehicles in rural areas. In future, this mobile technology will generate entrepreneur and employment opportunities for the youth of rural India.

CONCLUDING THOUGHTS

Biogas is a potential renewable energy and carbon neutral source for rural as well as for urban India. There is a need for tax incentives, support, and regulations in this direction from the government to enable our country to be self-reliant in the energy sector. Taking biogas generation as a base activity and compressing it for decentralized power production, cooking needs at highway motels, industrial complex, dairy, food processing units can be taken up, which will not only help us towards reducing unemployment and alleviating economy, it will also help us mitigate climate change by the use of bio-energy in an efficient way. AU

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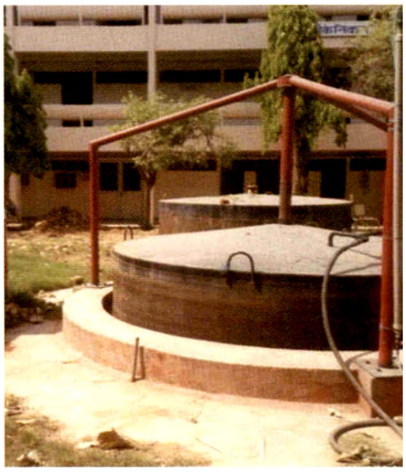
A biogas vehicle



Equipment at IIT-Delhi

TABLE 3: Global Scenario

Country	No. of Natural gas Vehicles	% all ngvs in world	Biomethane share in NGV market (%)
Iceland	255	0.00	100
Norway	762	0.01	10.0
Sweden	40,029	0.28	59.1
Switzerland	10,228	0.07	21
Germany	96,215	0.66	6
France	13,500	0.09	3
Finland	985	0.01	3

Source: Worldwide NGV Statistics, 2012

SMALL WIND ENERGY AND HYBRID SYSTEMS

Read on as **J P Singh** and **Hari Bhaskaran** take you through the nascent market for Small Wind Turbines and Small Wind–Solar Hybrid Systems in India and the role of the Ministry of New and Renewable Energy in promoting the scheme.

> THE POTENTIAL MARKET FOR RENEWABLE ENERGY BASED MICRO GENERATION AS PER A STUDY CONDUCTED BY WORLD INSTITUTE OF SUSTAINABLE ENERGY (WISE) (IN 2009) IS ESTIMATED AT 83,000+ MW. A SIZABLE POTENTIAL OUT OF THE ESTIMATED 83,000 MW MICRO-GENERATION POTENTIAL IN INDIA CAN BE DEVELOPED USING SWT AND WIND–SOLAR HYBRID SYSTEMS.

Small Wind Turbines (SWTs) and Small Wind–Solar Hybrid Systems (SWES) are becoming more popular worldwide as the technology matures. These systems can play a major role in decentralized energy generation and its utilization and can potentially reduce the pressures on centralized generation systems and transmission and distribution networks. Presently, a small annual market — a few hundred kilowatts — for small wind and wind–solar hybrid systems exists in the country. The market is driven mostly by the capital subsidy programme of the Ministry of New and Renewable Energy (MNRE), Government of India, started way back in 1994–95. Besides the subsidy-driven market, a non-subsidy market also exists. As on 28 February 2014, the total cumulative installation of SWTs/ SWES in India was 2.182 MW under the subsidy programme. However, the potential market for renewable energy based micro generation as per a study conducted by World Institute of Sustainable Energy (WISE) (in 2009) is estimated at 83,000+ MW. This covers applications such as rural electrification, pump energization, communication towers, replacement of diesel-based captive power plants, and replacing or supporting UPS and inverters. A sizable potential out of the estimated 83,000 MW micro-generation potential in India can be developed using SWT and wind–solar hybrid systems.

Suzlon 'One-Earth' »

PROGRAMME AND PROJECT IMPLEMENTATION

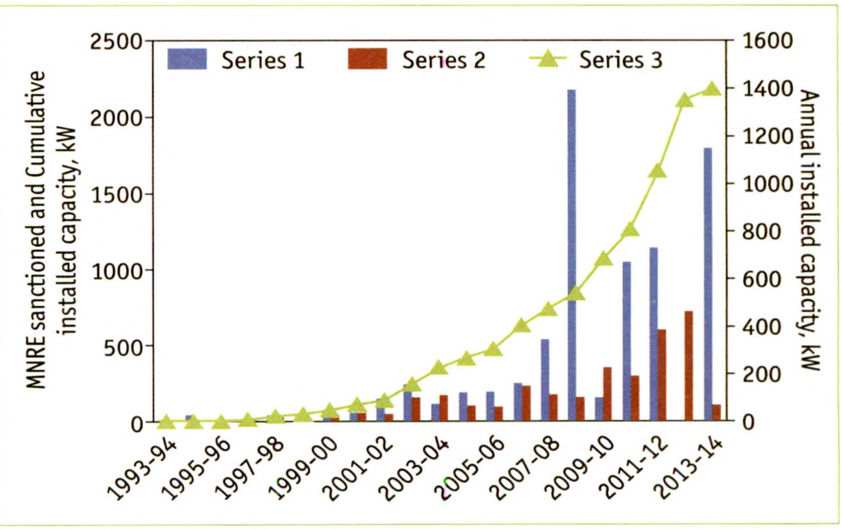


Figure 1: Small wind and hybrid system installations in India

The present mechanism of promoting renewable energy systems including SWTs in India is through the State Nodal Agencies (SNAs) and consulting organizations. Suppliers and manufacturers of SWTs and hybrid systems are mainly involved in promotion and deployment. The MNRE is responsible for formulating the policies for development and promotion of different renewable energy systems, including SWTs and hybrid systems at the national level. The MNRE also supports a programme for wind resource assessment in the country through C-WET. Basically, projects on SWTs and wind–solar hybrid systems can be implemented through a subsidy by the MNRE routed through SNAs or through non-subsidy projects or direct sales by manufacturers, suppliers, or system integrators.

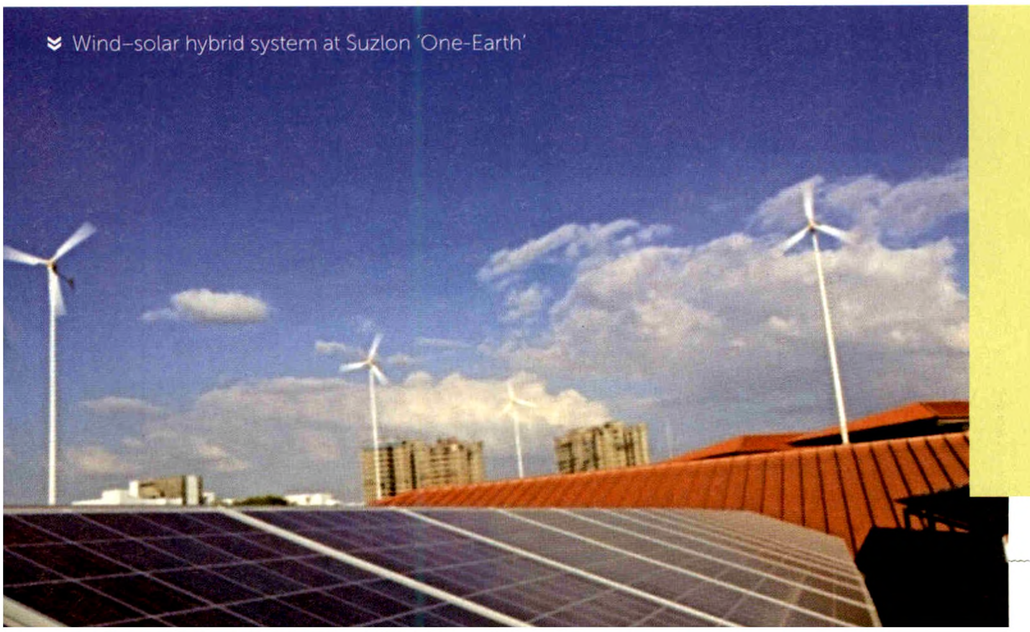
The present MNRE scheme for SWTs and hybrid systems covers aero-generators up to 100 kW. The maximum-rated capacity of individual aero-generators that can be used in a hybrid system will be 100 kW each; however, MNRE support for installation of a wind–solar hybrid system will be restricted to a maximum system capacity of 50 kW. Imported and indigenously manufactured or assembled aero-generators are covered under the scheme. The manufacturers will have to get their aero generator model/s empanelled with MNRE based on type testing/certification as per IEC 61400-2 and IEC 61400-12-1 for design requirement and power performance and for safety as per the empanelment procedure evolved by C-WET, Chennai. Stand-alone hybrid systems are also covered under the scheme.

IMPLEMENTATION IN INDIA

The MNRE initiated an exclusive programme in 1994–95 for small wind energy and hybrid systems. Although the programme helped to promote awareness of small wind systems in India, it created interest only among very few users and is yet to make a real impact like that seen in other countries the world over. The programme

One Earth: Suzlon Energy Ltd's Corporate Office, Pune

India's first mega urban wind park hybrid system has been constructed at One Earth, Suzlon Energy Ltd's corporate complex, Hadpasar, Pune. This system consists of a 155 kW wind–solar hybrid system. Aero-generators are installed along the periphery of Suzlon's building along with a building-integrated PV system. The system comprises 85.5 kW of wind (18 aero-generators of 4.75 kW each) and 69.33 kW of solar including 13.44 kW building-integrated PV systems, totalling to 154.83 kW. The total system cost is estimated at Rs 32 lakh. This system is designed for total annual generation of 1,85,000–2,25,000 kWh and is likely to meet about 5 per cent of the energy consumption of Suzlon's corporate complex.



Wind–solar hybrid system at Suzlon 'One-Earth' is implemented through state nodal agencies mainly in Maharashtra, Gujarat, Tamil Nadu, Karnataka, and Goa. Manufacturers of aero-generators and wind–solar hybrid systems are also eligible to market the systems directly to users. The programme is being extended to other potential states. The development path of wind–solar hybrid systems sanctioned by MNRE in India since 1994 is summarized in Figure 1.

Cumulative installed capacity (kW) in Figure 1 represent subsidy-based SWT wind–solar hybrid projects. The cumulative capacity addition of aero generators and wind–solar hybrid systems up to February 2014 was 2,182 kW. From 1993–94 to 2001–02, MNRE sanctioned, on average, about 30 kW a year; however, only a small proportion of this figure was actually installed. Sales of aero generators and hybrid systems increased from 2002–03 and the annual increase in sanctioned capacity was up to 300 kW. This scenario has changed from 2009, and SWT systems have represented diagonal growth from 2009–10 with 1,333 kW installed so far in the country, which is about 61 per cent of the cumulative installations. During the 11th Five Year Plan, almost 1,020 kW capacity was added against 488 kW during the 10th Plan. The increased sanctioned and installed capacity during the 11th Plan shows wider and increasing acceptance of the technology.

NEED OF GRID-INTERACTIVE HYBRID SYSTEMS IN INDIA

Grid-tied wind–solar hybrid systems are useful in coping with the widening gap between supply and demand of electricity. It is important to analyse the application areas of grid-tied and stand-alone SWT systems in India. The application areas for grid-tied SWT systems may be various industries and commercial establishments using diesel generators for back-up power or residences with ample roof space available depending upon economic feasibility. However, before promoting grid-tied SWT systems in India, the research group strongly feels that the SWT technology should first be customized to Indian conditions and then standardized. Interconnectivity issues, types of metering, and tariff philosophies need to be analysed before promoting such systems.

Gamesa Wind Turbine Private Ltd's Corporate office, Chennai

A 40.4 kW capacity grid-connected wind–solar hybrid system has been installed on the terrace of Gamesa's corporate office building in Chennai. It is a rooftop-based hybrid system constructed and supplied by Unitron Energy and commissioned in November 2011. Four units of 5.1 kW Unitron make small wind turbines and 20 kW solar panels are installed on the terrace of the 9-storey building.

Currently, no substantial work being pursued in this area of grid-connectivity of small wind turbines in India. However, one such grid-connected wind–solar hybrid system of 40.4 kW capacity is installed at Gamesa Wind Turbine Pvt. Ltd in Chennai. This project is envisaged to be the first-of-its-kind demonstrating the feasibility of large-scale installation of grid-connected small renewable systems.

Most rural locations in India have a weak grid characterized by heavy voltage fluctuations and low availability and reliability of electric power. Electricity generation from wind using small wind turbines is an established technology today. The need for reliable power to support the growing commercial and domestic energy requirements of rural consumers as well as establishments at remote locations necessitates large-scale deployment and interconnection of small wind farms to the local grid. Grid interconnection avoids the losses involved in transmission of electricity from the source to the user point. Moreover, the SWT system user benefits by avoiding the cost of storage components, which forms a major portion of the capital and maintenance costs. In this way, the grid acts like a bank for the electricity produced by the systems and thus helps SWT systems to be more cost-competitive and user-friendly as compared to conventional options.

> CONSIDERING THE FISCAL BENEFITS AVAILABLE FOR HYBRID SYSTEMS, THE AVERAGE LIFE CYCLE COST OF ENERGY FROM A HYBRID SYSTEM CAN BE ESTIMATED AT RS 11–13 PER UNIT. THIS IS COMPARABLE TO THE COST OF ENERGY GENERATED FROM FOSSIL FUELS AS CAPTIVE POWER AT PRESENT.

ECONOMICS AND COST–BENEFIT ANALYSIS

Although SWT and hybrid systems involve a significant initial investment, they can be competitive with conventional energy sources when we account for a lifetime of reduced or altogether avoided utility energy costs, especially considering the escalating fuel costs. A kilowatt aero-generator system should produce about 3 to 4 kWh at wind speeds of 4–5 m/sec. Similarly, a kilowatt solar energy system generates about 4 to 5 kWh per day. However, as a thumb rule, 60–70 per cent wind and 40–30 per cent solar is the ideal combination for most locations in the country, which can generate about 3.5 to 6 kWh a day, depending on available resources. In high wind areas, higher wind component is preferred.

Considering the fiscal benefits available for hybrid systems, the average life cycle cost of energy from a hybrid system can be estimated at Rs 11–13 per unit. This is comparable to the cost of energy generated from fossil fuels as captive power at present. This SWT cost of Rs 11–13 is nearly fixed for the next 20 to 25 years, whereas energy costs for fossil fuel (diesel) generation can be estimated at Rs 17 per unit. Considering the present level of subsidies (up to 33%) on diesel and the northward prices of diesel, SWT and wind–solar technologies are competitive even today and can potentially replace diesel generation.

SUMMING UP

In India, currently more than 36 manufacturers and system integrators are offering about 152 models and also exporting them to both developing and developed countries. As the power crisis across the country deepens, the need to deploy such micro-generation systems on mass scale is felt more and more acutely. As the cost of energy generated from diesel is pretty high, it makes greater sense to reduce the consumption of diesel to generate electricity. More applications need to be developed with wind–solar hybrids in the stand-alone or grid-connected mode. AU

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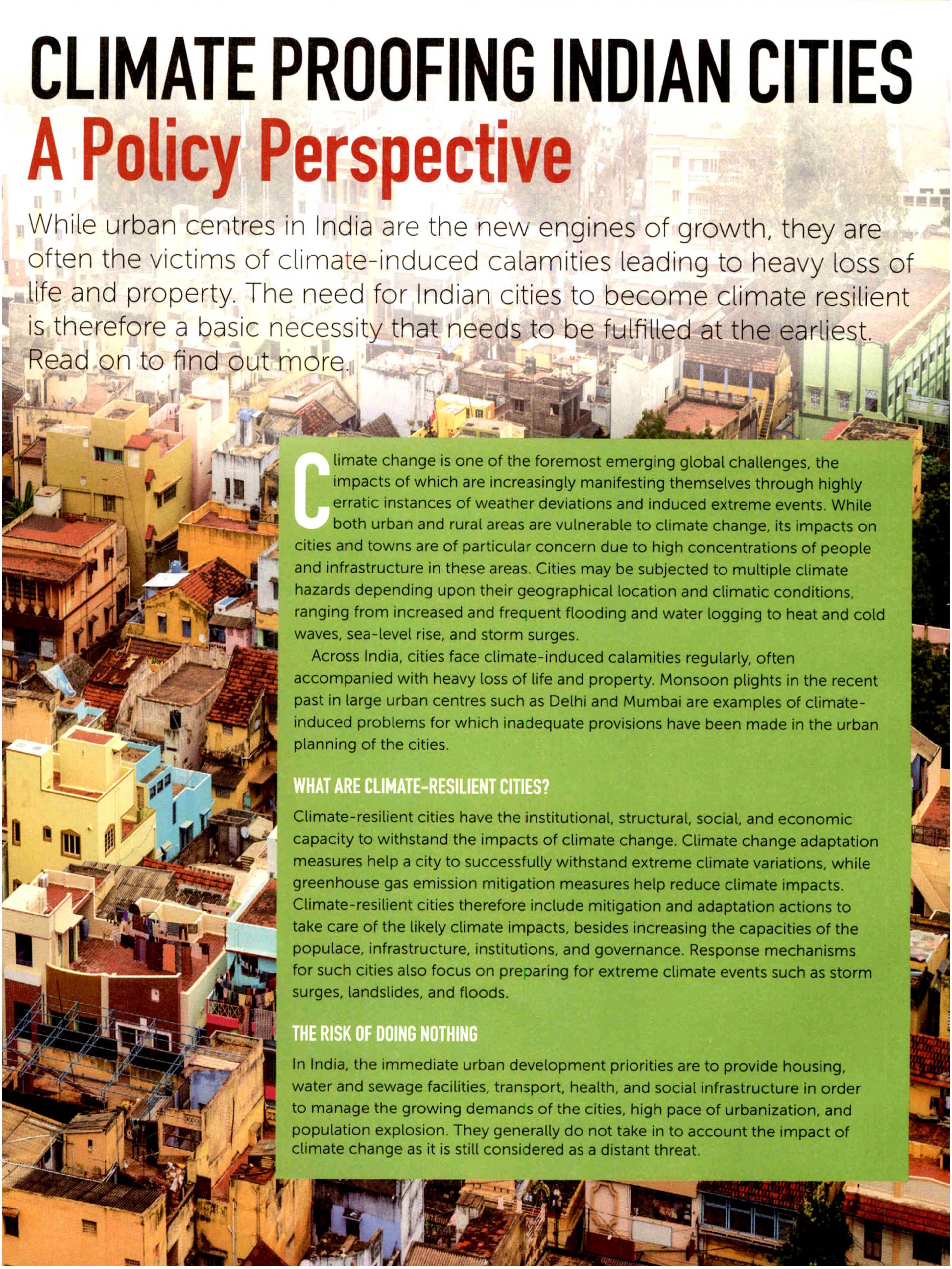
Hybrid system site at Tinkai, Manipur

CLIMATE PROOFING INDIAN CITIES

A Policy Perspective



While urban centres in India are the new engines of growth, they are often the victims of climate-induced calamities leading to heavy loss of life and property. The need for Indian cities to become climate resilient is therefore a basic necessity that needs to be fulfilled at the earliest. Read on to find out more.

Climate change is one of the foremost emerging global challenges, the impacts of which are increasingly manifesting themselves through highly erratic instances of weather deviations and induced extreme events. While both urban and rural areas are vulnerable to climate change, its impacts on cities and towns are of particular concern due to high concentrations of people and infrastructure in these areas. Cities may be subjected to multiple climate hazards depending upon their geographical location and climatic conditions, ranging from increased and frequent flooding and water logging to heat and cold waves, sea-level rise, and storm surges.

Across India, cities face climate-induced calamities regularly, often accompanied with heavy loss of life and property. Monsoon plights in the recent past in large urban centres such as Delhi and Mumbai are examples of climate-induced problems for which inadequate provisions have been made in the urban planning of the cities.

WHAT ARE CLIMATE-RESILIENT CITIES?

Climate-resilient cities have the institutional, structural, social, and economic capacity to withstand the impacts of climate change. Climate change adaptation measures help a city to successfully withstand extreme climate variations, while greenhouse gas emission mitigation measures help reduce climate impacts. Climate-resilient cities therefore include mitigation and adaptation actions to take care of the likely climate impacts, besides increasing the capacities of the populace, infrastructure, institutions, and governance. Response mechanisms for such cities also focus on preparing for extreme climate events such as storm surges, landslides, and floods.

THE RISK OF DOING NOTHING

In India, the immediate urban development priorities are to provide housing, water and sewage facilities, transport, health, and social infrastructure in order to manage the growing demands of the cities, high pace of urbanization, and population explosion. They generally do not take in to account the impact of climate change as it is still considered as a distant threat.

However, not taking into account the impacts of climate change at the urban planning stage itself, can lead to huge economic losses, negative health impacts, associated with high social cost burden, particularly among the vulnerable groups such as the poor, disabled, elderly, and children. It is thus important to consider climate resilience as an important urban agenda as it is a starting point towards addressing climate-related impacts and preparing cities for unforeseen climate-related extreme events and variability.

HOW ARE OTHER COUNTRIES ADDRESSING URBAN CLIMATE RESILIENCE?

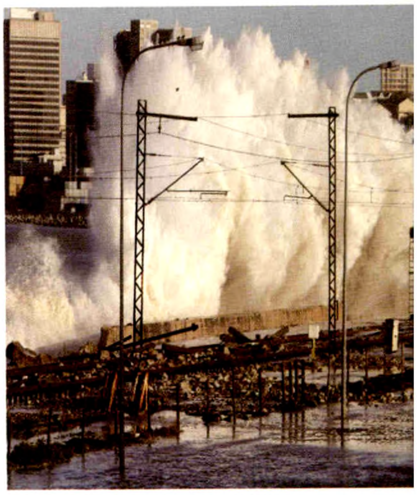
Realizing that climate change is a reality and the urgency to address climate-related extreme events, city governments across the globe are taking policy actions to prepare their cities to face the brunt of climate change impacts. Table 1 summarizes a few of them.

TABLE 1: Key Features of Resilience Strategy: Selected Case Studies

City/Urban Local Body	Climate Action Taken/Name of the Strategy	Key Features
London, The UK	The City of London's Climate Adaptation Strategy in 2007 (The City of London Corporation, 2007)	▪ Systematic process of adaptation planning in the city with assigned responsibilities to the institutions and proposed mechanisms for implementation. ▪ Prescribed the corporation to climate proof its policies and aligned itself with existing policies, guidelines, and regulations. ▪ In 2008, the Greater London Authority Bill (GLA Bill) 2007 was enacted which assigned the duty of climate protection for the city of London to its Mayor.
Halifax Regional Municipality, Canada	A six-step strategy in response to the physical and social impacts of extreme weather conditions (Hurricane Juan in September 2003 and the 'Great Maritime Blizzard' of February 2004) (Halifax Regional Municipality, 2007)	▪ Adopts a systematic approach that undertakes climate impact assessments, identifies risks and vulnerabilities, and takes into account the governance profile of the city. ▪ Assigns institutions various measures that each public department may take to facilitate adaptation within the sector concerned.
New York, The USA	New York City's sustainability plan (PLaNYC) (The City of New York, 2007)	Dynamic strategy targeting the year 2030, brings together about 40 agencies to work coherently towards a sustainable and green city. Came up in 2007 with an objective to: ▪ Prepare the city for housing ever increasing number of residents, ▪ Strengthen city's economy, ▪ Adapt to climate change, and ▪ Enhance the quality of life for the residents of New York.
	The New York City Panel on Climate Change (NPCC)	Set up in 2008 to advise the city on climate change impacts. Talks about bringing in changes in building and zoning regulations and integrating climate change projections into emergency management and preparedness.
Cape Town, South Africa	Framework for Adaptation to Climate Change in the City of Cape Town (FAC4T) (Mukheibir and Ziervogel, 2006)	▪ An overarching framework for a city-wide approach to reducing vulnerability to climate impacts in response to the high likelihood of climate-induced warming, rainfall change, and extreme events projected for the region. ▪ Defines a mechanism for integration in national and provincial acts.

URBAN RESILIENCE

Urban resilience can be defined as "the ability of cities to tolerate alteration before reorganizing around a new set of structures and processes" (Alberti et al., 2003). "Resilient cities in the light of climate change should be able to develop plans for future development and growth, bearing in mind the climate impacts that the urban systems are likely to face" (Prasad et al., 2009). "Building resilience also means strengthening capacities of social agents to access urban systems and to develop adaptive responses", (Opitz-Stapleton and MacClune, 2012:4).



> CLIMATE-RESILIENT CITIES INCLUDE MITIGATION AND ADAPTATION ACTIONS TO TAKE CARE OF THE LIKELY CLIMATE IMPACTS, BESIDES INCREASING THE CAPACITIES OF THE POPULACE, INFRASTRUCTURE, INSTITUTIONS, AND GOVERNANCE.

PREPARING FOR AN URBAN CLIMATE RESILIENCE POLICY

Action to address climate change in urban areas should be multi-level, involving national-, state-, and city-level governments, as well as multi-sectoral in its approach. Policies aiming at action should bring forth the importance of and the need to introduce urban climate resilience into the urban planning framework, draw out a structure of the institutions and regulations needed to implement the same, and identify windows for financing the actions. They should begin with facilitating the preparatory actions on which the cities would base their actions towards resilience. This includes a risk and vulnerability analysis of cities to potential climate impacts in the next 15–30 years. This requires past climate data and future projections of climate and various other sectoral datasets, to help assess the vulnerability, and coping capacity of city systems to climate events. The second important milestone in this discourse is to provide for need-based area-specific training for officials at all levels to enable planning for climate resilience and preparedness for dealing with any climate-induced emergency situation. There is also need for increased awareness among citizens on the matter.

> “ AN URBAN RESILIENCE POLICY MUST MAKE A CASE FOR CITIES TO CONDUCT RISK AND VULNERABILITY ANALYSES TO UNDERSTAND THEIR SPECIFIC REQUIREMENTS FOR RESILIENCE BUILDING AND DEVELOP CITY SPECIFIC STRATEGIES FOR ADAPTATION AND MITIGATION.

Making a case for climate-related actions and investment

An urban resilience policy must make a case for cities to conduct risk and vulnerability analyses to understand their specific requirements for resilience building and develop city specific strategies for adaptation and mitigation.

Climate projections

Climate resilience is based on parameters related to climate, its variability, and change. Studying past climate trends and developing climate projections therefore are essential components of risk and vulnerability assessments. Climate modelling is a specialized field which requires capacity building and technical expertise, which could be achieved by forming a repository of institutions and experts at the state or national level to act as resource persons for cities obtaining climate projections.

Data

Most cities in India lack the proper information systems required for addressing the various aspects of climate change impacts; e.g., data on weather anomalies, frequency, and extent of urban floods. Integrating resilience planning in the urban planning process requires very specific data sets on various local and regional climate parameters. Hence, maintaining a repository of city and region specific data using Management Information Systems (MIS) would be an essential step, which could be used to develop time-series and spatial data bases in this regard.

Capacity building

Climate resilience is a new concept in India, requiring specific technical know-how and data for cities to draw up their resilience plans. It also needs awareness generation to be built among civil society to foster interest and support. The policy to facilitate action to climate-proofing cities must ensure capacity building, competence, and adaptability at various levels of urban governance that would eventually be dealing with mitigation and/or adaptive practices on ground. There is a need for creation and dissemination of knowledge that penetrates from local to federal level of governance, across communities to sensitize various stakeholders and facilitate action towards climate resilience.

A perspective policy must make adequate human resource development plans for all the levels of urban governance. Designing specific training programmes to suit local variations and availability of adequate resources for the training programmes would be a prerequisite. The broad objectives of the capacity building would be to:

- Generate awareness about climate change impacts on urban areas

- Acquaint stakeholders with the principles of resilience planning and its benefits for the cities' sustainability and development
- Develop techniques, methods, and tools for assessment of climate risks and vulnerability to climate change in cities. Customized material such as toolkits, guidelines, and case studies can be developed for use in resilience planning
- Strengthen the role of institutions and governance in fostering climate-resilient development

Multi-level engagement

Resilience planning is successful and apt when an integrated approach to various urban sectoral needs is followed through continuous stakeholder consultations, inter-departmental and institutional coordination and community participation. The policy should establish a mechanism to institutionalize the process of this multi-stakeholder engagement; e.g., the national government could incorporate climate resilience in the reforms agenda and resource planning under national schemes, and bring in incentive mechanisms for states and cities. They could also facilitate partnerships with international and non-government actors for technical and implementation support. Cities would need to assess and understand their vulnerability and develop responses to climate-proof urban systems.

> A PERSPECTIVE POLICY MUST MAKE ADEQUATE HUMAN RESOURCE DEVELOPMENT PLANS FOR ALL THE LEVELS OF URBAN GOVERNANCE. DESIGNING SPECIFIC TRAINING PROGRAMMES TO SUIT LOCAL VARIATIONS AND AVAILABILITY OF ADEQUATE RESOURCES FOR THE TRAINING PROGRAMMES WOULD BE A PREREQUISITE.

Integrating climate resilience into urban development laws and regulations

Considering that the resilience options are not independent of the regular sustainability goals and planning needs of the city, it is pertinent to dovetail climate resilience to the urban development framework. This means integrating climate-related issues and addressing them through the state-level acts and regulations. Also, resilience interventions could be included into the development regulations of the cities, e.g., building bylaws, development controls, and zoning regulations. There is merit in establishing a nodal body at the city level; e.g., the Municipal Corporation. Capturing local communities' interest and involvement could be one of the responsibilities of the nodal body.

Financing urban resilience

Reinforcing and climate proofing existing infrastructure would require additional funds. Therefore, financial allocation for resilience building and adaptation projects would also be an integral part of the proposed policy. Establishing national- and state-level climate funds and resource planning under various national schemes such as the JNNURM and the UIDSSMT can go a long way in this direction.

CONCLUSION

The east coast of India had faced two large cyclones — Phailin and Helen — affecting the states of Andhra Pradesh and Odisha within a period of two months in 2013. The floods at Uttarakhand in June 2013 is yet another example. Even though these events cannot be attributed completely to impacts of global climate change, their severity and the volume of damage that they have caused demonstrate that actions for resilience and climate-proofing settlements are all the more important. They call for better planning and preparedness to deal with new and unforeseen climatic changes in the future. There is a need for a paradigm shift in which the cities of today are planned and managed. Integration of a climate resilience agenda has the potential to systematically build resilience of cities and its systems, reduce vulnerability and achieve the desired development goal. A policy towards this end is an important stepping stone to achieve the larger goal of sustainable and climate-resilient cities. AU

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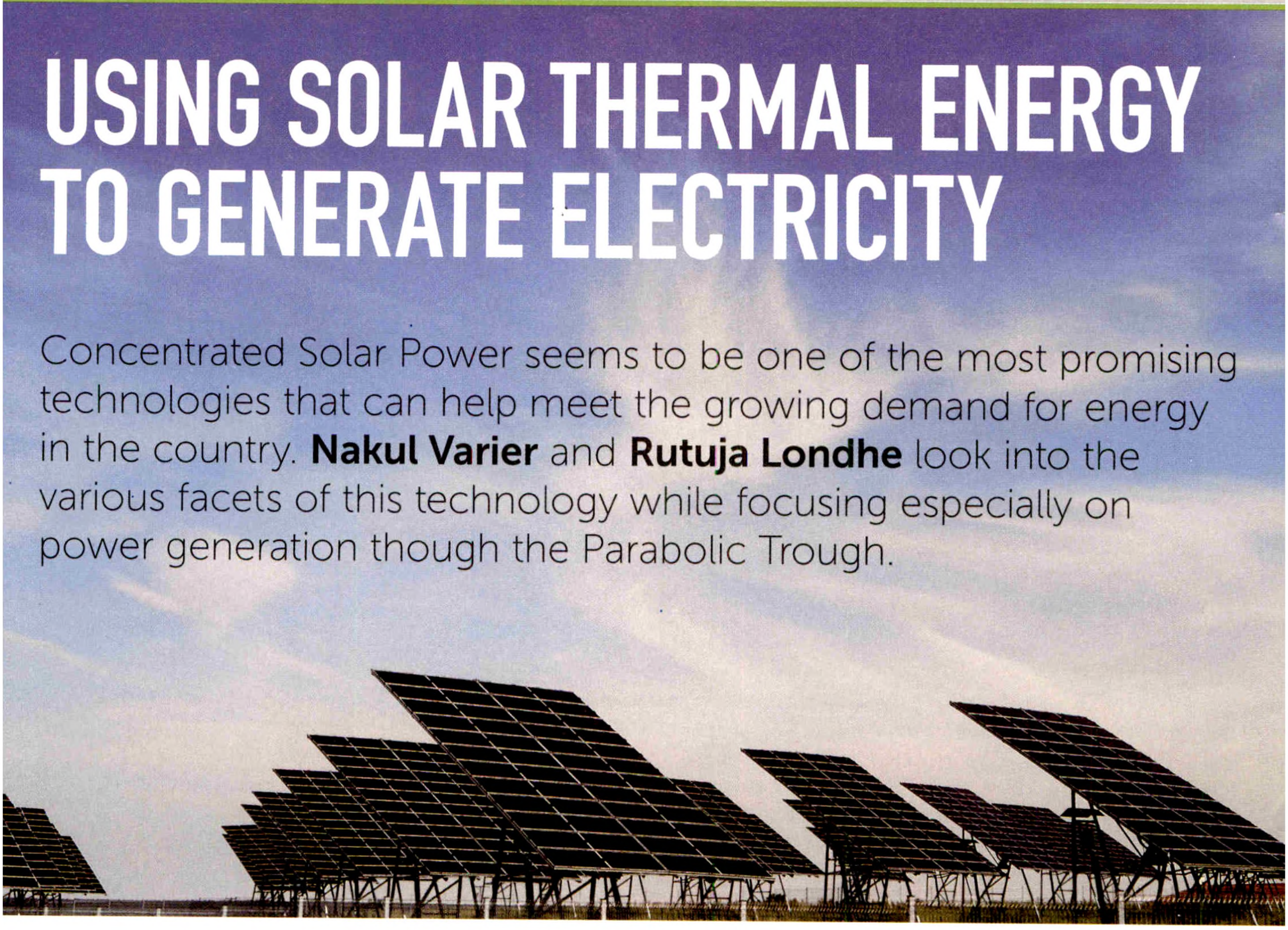
USING SOLAR THERMAL ENERGY TO GENERATE ELECTRICITY



Concentrated Solar Power seems to be one of the most promising technologies that can help meet the growing demand for energy in the country. **Nakul Varier** and **Rutuja Londhe** look into the various facets of this technology while focusing especially on power generation though the Parabolic Trough.

Energy plays a vital role in the economic growth of a developing country like India. Due to rapid depletion of fossil fuels, alternative renewable energy sources should be developed and implemented in order to cope with such humungous energy requirements. Solar energy seems to be one of the most promising alternative energy resources. Solar radiation consists of both light and heat energy. This article focuses on harnessing heat energy from solar radiation to generate electricity. The technology used for this purpose is known as Concentrated Solar Power (CSP).

> CSP USES VARIOUS MIRROR CONFIGURATIONS TO FOCUS THE SUN'S RADIATION ON TO A RECEIVER THAT ABSORBS THERMAL ENERGY TO DRIVE STEAM TURBINES CONNECTED TO GENERATORS, THUS PRODUCING ELECTRICITY.

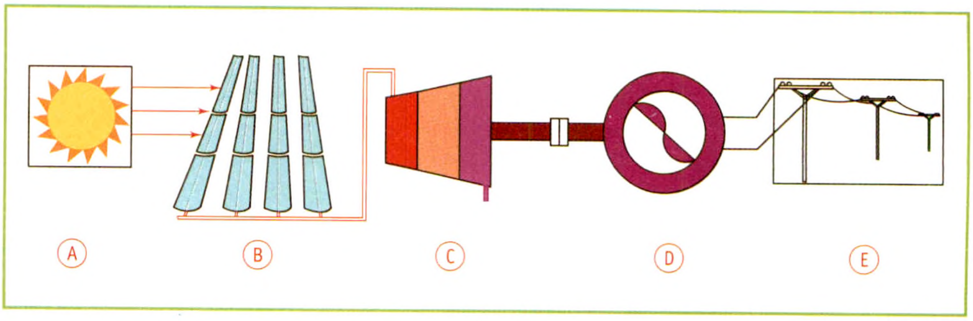


Figure 1: Block Diagram of CSP

Notes: A Solar energy source, B Collector field, C Steam turbine, D Generator, and E Transmission system

BASIC WORKING PRINCIPLE

CSP uses various mirror configurations to focus the sun's radiation on to a receiver. The receiver absorbs thermal energy, comprising mainly infrared rays in variable wavelengths, from the focused radiation. This energy or heat is used to drive a series of steam turbines connected to generators, thus producing electricity. Figure 1 depicts the various methods that can be used for focusing the sun's radiation on to a receiver.

TECHNOLOGIES USED

There are four basic technologies which are currently in use:

- Dish Stirling
- Central Receiver Plants
- Fresnel's Reflector
- Parabolic Trough

Different technologies produce different peak temperatures and have different efficiencies, due to differences in the way they track the sun and focus the the solar radiation.

Dish Stirling

A Dish Stirling system uses a large reflective dish (has a similar shape as that of a satellite television dish) to focus all the sun's radiation/sunlight striking the dish up onto the reflector's focal point. The tracking system of the reflector tracks the sun along two axes. It has a receiver at the focal point, which consists of a working fluid, capturing the heat and transforming it into electricity using a stirling engine. Dish Stirling is known to have the highest efficiency of all solar technologies. It has an efficiency of 30 per cent as compared to solar Photo Voltaic (PV) technology, which has an efficiency of approximately 15 per cent. The world record for solar to electric efficiency was set at 31.25 per cent by Stirling Energy Systems (SEC) dishes at the National Solar Thermal Test Facility (NSTTF) in New Mexico.

Central Receiver Plants

The Central Receiver Plant, also known as 'Central Tower' power plant, uses a central receiver placed on top of a tower to receive the focused sunlight. It uses an array of flat, movable mirrors (called heliostats) to focus the sun's rays on a collector tower (the target). The receiver placed at the top of the tower consists of fluid deposits, generally seawater, which is heated to about 500–1,000 °C. It is then used as a heat source for power generation. The Solar Two in Daggett, California, and the CESA-1 in Plataforma Solar de Almeria, Spain, are the representative demonstration plants. The Planta Solar 10 (PS10) in Sanlucar la Mayor, Spain, is the first commercial utility-scale central tower plant in the world.

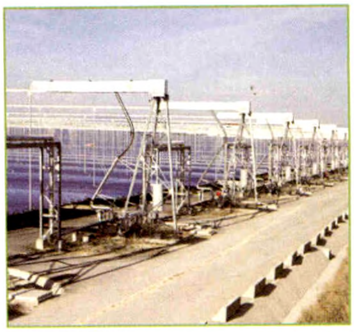
Fresnel's Reflector

A linear Fresnel's Reflector power plant uses a series of long, narrow mirrors with shallow-curvature (or even flat) to focus thermal energy from the sun's radiation onto one or more linear receivers positioned above the mirrors. These mirrors are capable of concentrating the sun's energy to approximately 30 times its normal intensity. The reflectors are located at the base of the system and converges the sun's rays into the absorber. On completion of phase 1 of the Rajasthan 125 MW CSP Project in 2013, it will be the largest linear Fresnel Reflector CSP power plant in Asia.

> THE SOLANA GENERATING STATION, ARIZONA, IS THE LARGEST PARABOLIC TROUGH PLANT IN OPERATION. IT HAS A TOTAL CAPACITY OF 280 MW WHICH IS ENOUGH TO POWER 70,000 HOMES, THUS AVOIDING AROUND 475,000 TONNES OF CO_2.

Dish Stirling

Central Receiver Plant



Fresnel's Reflector

Photo 4: Parabolic Trough

> PARABOLIC TROUGH PLANTS PRIMARILY CONSIST OF THREE PARTS – THE SOLAR FIELD, THE STORAGE SYSTEM, AND THE POWER PLANT BLOCK.

Parabolic Trough

A parabolic trough is a type of solar thermal collector that is straight in one dimension and curved as a parabola in the other two dimensions. It is lined with polished metal mirrors. The solar radiation is captured and concentrated by long rows of Parabolic Troughs onto a receiver positioned along the reflector's focal line. The reflector uses a single axis tracking system to track the sun's movement. The heat generated in this way is enough to produce the required steam. The Solana Generating Station near Gila Bend, Arizona, is the largest parabolic trough plant in operation. It has a total capacity of 280 MW which is enough to power 70,000 homes, thus avoiding around 475,000 tonnes of CO_2.

Among all the above mentioned systems, the parabolic trough systems are the most developed and widely used. This article will therefore focus on the working of parabolic trough plants.

POWER GENERATION USING PARABOLIC TROUGH PLANTS' COMPONENTS

Parabolic trough plants primarily consist of three parts – the solar field, the storage system, and the power plant block (Figure 2).

Solar Fields

The Solar Field consists of arrays of parabolic-shaped concave mirrors known as parabolic. These parabolic troughs are around six meters high and several hundred metres long. These mirrors are made from silver-coated white glass which are about 4 to 5 mm thick. In spite of their humongous size, they are aligned with millimetre precision. The rows run in a north–south direction and track the sun from east to west during the course of the day. Over 98 per cent of the solar radiation that falls on the mirrors is reflected onto the absorber tube, which is fixed along the focal line of the mirrors. Thermax India Pvt. Ltd, First ESCO India Pvt. Ltd, Soltigua, TSK Flagsol, etc., are some of the manufacturers of parabolic trough collectors in India and around the world.

Absorber Tube

The Absorber Tube consists of a heat transfer medium, heated to around 400 °C by concentrated sunlight. The absorber tube is made of an aluminum alloy metal which is surrounded by a glass tube. Aluminum alloy possesses high temperature and pressure-resisting capabilities. The vacuum created between the metal tube and glass tube acts as an insulating medium, thus reducing heat loss. Almeco Solar is a manufacturer of absorber tubes.

Storage System

The Storage System consists of a cold tank comprising molten salt maintained at about 280 °C and a hot tank containing molten salt at a higher temperature of about 380 °C. Nitrates of potassium and sodium generally form the primary composition of molten salt.

> A PROPERLY DESIGNED PLANT CAN PRODUCE ELECTRICITY JUST BY USING SOLAR ENERGY.

Power Plant Block

The Power Plant Block consists of all the components and equipment necessary for generating electricity. It mainly comprises steam turbines, generators, transformers, transmission lines, etc.

OPERATION

Infrared radiation, consisting of most of the thermal energy present in solar radiation, is focused along the focal line using parabolic-shaped mirrors, where the absorber tubes that are intended to be heated are positioned. The heat is then transferred to the heat transfer medium inside the tube (generally oil) by convection. Then this heated oil is sent to the heat exchangers where steam produced is used to run the steam turbines, thus generating electricity. A properly designed plant can produce electricity just by using solar energy.

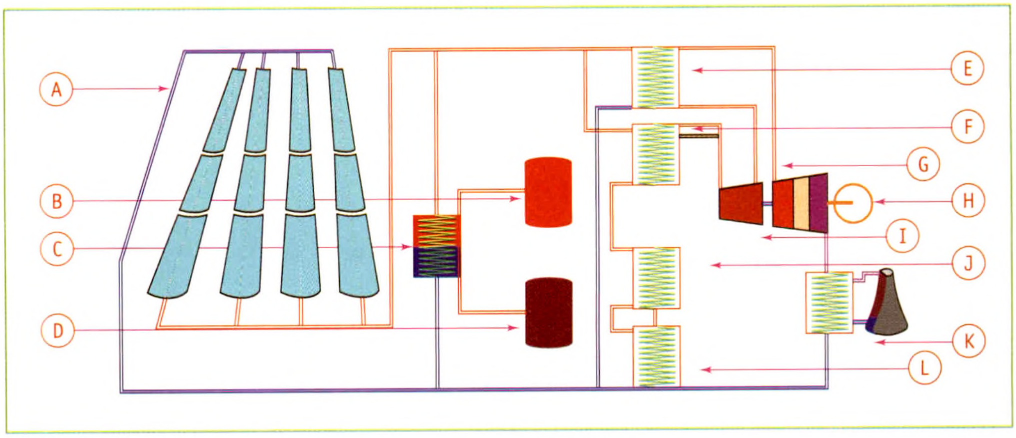


Figure 2: Layout of a typical parabolic trough plant

Notes: A Solar field, B Hot tank, C Heat exchanger, D Cold tank, E Re-heater, F Super-heater, G Steam turbine, H Generator, J Vaporizer, L Economizer, K Condenser and cooling tower

The process of generating electricity during a 24 period can be divided into four parts:

- After sunrise (6 am to 9 pm)
- During the day (9 pm to 3 pm)
- In the evenings (3 pm to 6 pm)
- During night (after 6 pm till sunrise)

After sunrise: After sunrise, the parabolic troughs start tracking the sun and reflect the sun's energy onto the absorber tube, thus heating the oil inside it. This heated oil is then transferred to a heat exchanger, where steam is generated from water supplied from the cooling tower or the reservoir. This steam is used to drive the turbine connected to the generator to generate electricity. Since the sun's intensity is less during this period, there is only enough solar energy to power the steam turbine.

During the day: As the day progresses, the sun's intensity starts increasing gradually. The surplus energy received from the sun is stored in the form of molten salt. A part of the heated oil from the solar field is sent to a heat exchanger in the storage block where molten salt pumped from the cold storage tank is further heated from 280 °C to 380 °C, and is then sent to the hot storage tank. The rest of the heated oil is sent to the heat exchanger in the power block to generate steam. Thus, solar energy is simultaneously used for generating electricity as well as for heating the molten salt in the storage system.

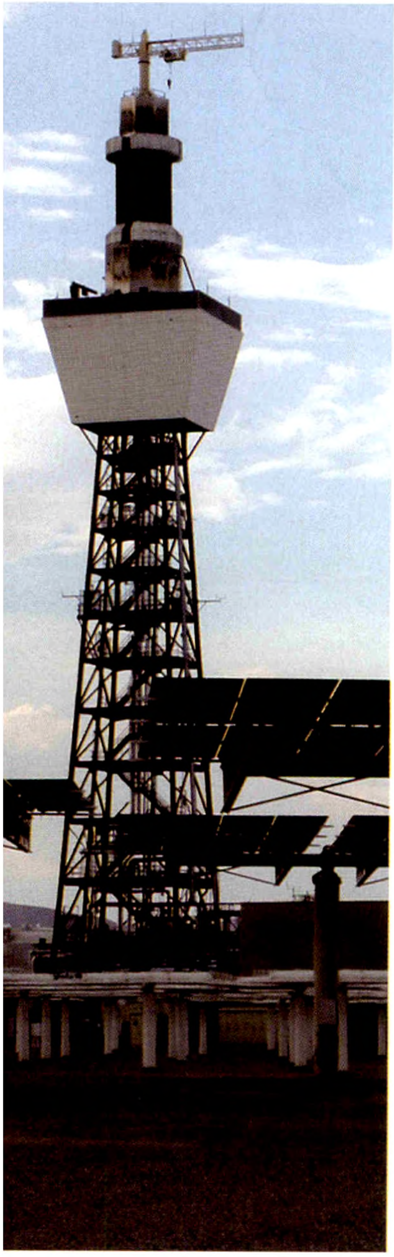
In the evenings: During this period, the energy to drive the turbine comes from the solar fields and the storage system. The molten salt from the hot tank is transferred to the cold tank through heat exchangers where the oil is heated and is sent to the power block.

During night: After sunset, thermal energy is exclusively provided by the storage system. If the storage system and solar fields are designed accordingly, the plant can operate for 24 hours. These solar plants can run in conjunction with other sources of energy, such as combustion of gas, biomass, etc. Such plants are known as hybrid plants.

> CURRENTLY, INDIA HAS ONLY 52.5 MW OF CSP IN OPERATION (OF WHICH, 50 MW IS CONTRIBUTED BY THE GODAWARI SOLAR THERMAL PLANT, LOCATED IN NORTHWEST RAJASTHAN).HOWEVER, THERE ARE SEVEN PROJECTS OF 470 MW AGGREGATE CAPACITY SCHEDULED UNDER THE FIRST PHASE OF THE JAWAHARLAL NEHRU NATIONAL SOLAR MISSION (JNNSM).

EFFICIENCY OF A PARABOLIC TROUGH

The efficiency and cost of the parabolic trough is influenced by structural stiffness, choice of materials, assembly tolerances, mirror cleanliness, and wear. Thus, high efficiency



> CSP HAS NUMEROUS ADVANTAGES AS IT HAS ZERO FUEL COSTS, GIVES PREDICTABLE 24*7 POWER, IS ENVIRONMENTAL FRIENDLY AS IT IS POLLUTION FREE, AND HAS NO GLOBAL WARMING EFFECTS.

can be obtained by proper designing and maintenance. Current performance estimate of the solar trough optical field efficiency is 54.2 per cent.

BENEFITS OF CSP

CSP has numerous advantages as it has zero fuel costs, gives predictable 24*7 power, is environmental friendly as it is pollution free, and has no global warming effects. It can be installed in deserts or other remote areas where the land is otherwise wasted, and thus can power neighbouring towns and villages.

ISSUES AND CHALLENGES

Apart from the high costs involved in the implementation of a plant, the other limiting factors include large water requirements for cooling purposes, location and size limitations, long gestation periods, etc. In order to be profitable, the plant should be operational for at least 25 years. Future technologies, therefore, have a high probability of making CSP obsolete. The plant may also pose ecological and cultural issues.

CONCLUSION

Solar power can play a significant role in creating a secure and diversified energy future. This technology is becoming commercially viable and is quickly expanding around the world. Currently, India has only 52.5 MW of CSP in operation (of which, 50 MW is contributed by the Godawari solar thermal plant, located in Northwest Rajasthan). However, there are seven projects of 470 MW aggregate capacity scheduled under the first phase of the Jawaharlal Nehru National Solar Mission (JNNSM). Private firms in India are planning to build a 250 MW solar thermal plant (largest in Asia) in Dhursur, Rajasthan, within the next few years. Within the next decade, solar thermal power plants will provide a significant contribution towards an efficient, economical, and environmentally benign energy supply in India. It is estimated that it could account for up to 25 per cent of the world's energy needs by 2050.

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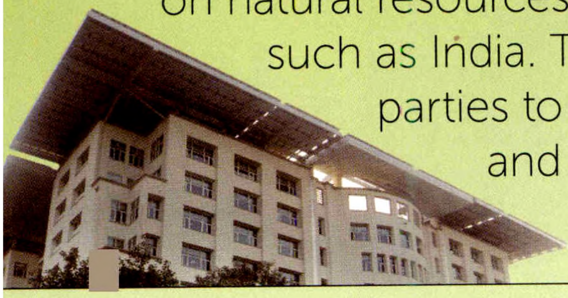
RENEWABLE ENERGY
INSTALLATION IN THE BUILDING SECTOR

Growth in the construction sector has created immense pressure on natural resources, especially in developing countries such as India. The time is thus ripe for all involved parties to look towards the use of renewables and harnessing energy from Green sources. **Swati Gupta** reports.

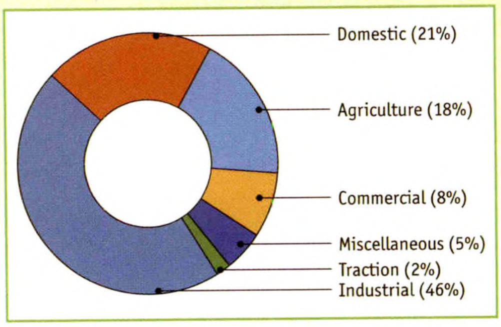


Unprecedented growth of human population has increased the demand for buildings to house them the world over. The pressure becomes immense in case of developing economies, such as India, where the building sector is one of the major contributors to the GDP growth and the graph of the sector has witnessed an exponential development. This economic growth has given rise to an enormous demand for buildings with a subsequent pressure on availability of resources to build and operate them.

Globally, buildings are responsible for at least 40 per cent energy usage. An estimated 42 per cent of the global water consumption and 50 per cent of the global raw material consumption are attributed to buildings when taking into account the manufacturing, construction, and operating period of buildings. In addition, building activities contribute to an estimated 50 per cent of the world's air pollution, 42 per cent of greenhouse gas emissions, 50 per cent of all water pollution, 48 per cent of all solid wastes, and 50 per cent of all Chlorofluorocarbons (CFCs) emission to the environment.

These statistics only go on to indicate that the building sector is a big energy guzzler and polluter of the environment. As per electricity consumption data between 1980 and 2009, energy consumption increased by almost seven times in the country, which corresponds to an annual growth rate of 7.1 per cent. Major increase was observed in the domestic consumption. The reason behind this increase was the inclusion of several million new households, which subsequently led to an increase in usage of electrical household appliances, such as refrigerators, air-conditioners, etc.

This data shows that an extraordinary rise in energy demand in this sector for the coming decade can be clearly visualized.

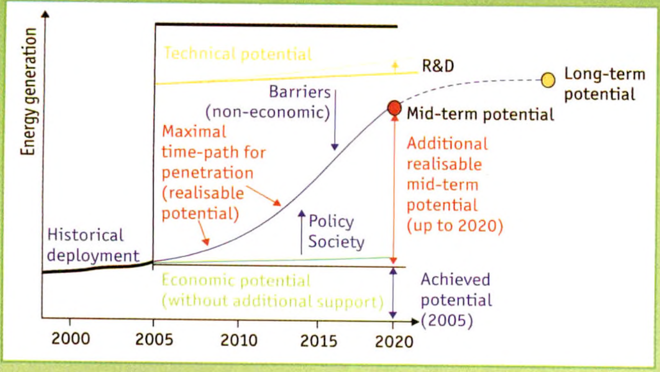


« Electricity consumption distribution in Indian context in 2008

ENERGY REQUIREMENT OF THE BUILDING SECTOR IN INDIA

Two of the major challenges in meeting the energy demand of the country are inefficiencies in energy generating processes and their dependency on conventional resources, such as coal and nuclear power. This creates a challenge in expanding our limits to supply sustainable energy to the growing demand. To counter this fact that we may not have enough resources to continue current growth rate, Renewable Energy (RE) has emerged as a promising alternative.

According to a report generated by Ernst and Young, in 2012, only 12 per cent of the overall energy generated was through renewable means, the rest was dependent on conventional energy sources. Though there is a huge



Energy Generation

Police Training School in Tasgaon, Sangli, Maharashtra

RE potential in India, it is still not tapped completely in the Indian context.

TECHNIQUES OF INSTALLING RENEWABLE ENERGY IN BUILDING

Solar photovoltaic and solar water heaters

Solar Photo Voltaic (SPV) cells can directly convert solar energy into electrical energy and can be conveniently installed on any roof top receiving enough sunlight. A small PV system is capable of providing sufficient electricity to power a single home or run an isolated, whereas large grid-connected photovoltaic power systems are capable of providing energy supply for multiple consumers. The electricity generated can be stored, used directly, and fed into a large electricity grid powered by central generation plants, or combined with one or many domestic electricity generators to feed into a small electrical grid (smart grid). Building integrated SPVs are also gaining popularity where panels are installed as building materials; for example, skylights or façade integration.

Solar water heater devices can be directly installed where heat is transferred from the collector installed at the roof top of the building to water storage tank for supplying hot water to the occupants.

Wind power

Like solar energy, wind energy is also a free energy resource, but it is much intermittent than solar. Nevertheless, wherever it is feasible, wind is a lesser expensive way of generating electricity than solar power. For example, the Police Training School in Tasgaon, Sangli, Maharashtra, has installed 13 windmills on its roof with power capacity of 5.5 kW each to meet its annual energy demand.

Geothermal energy

Geothermal energy is the thermal energy generated and stored in the earth. There are two ways of using geothermal energy in a building. The heat stored in the layers of the earth's core can be used to produce steam for driving a turbine to produce electricity. Another way is to utilize earth's property of maintaining a constant temperature at around 4 to 5 metre depth irrespective of seasonal changes. This way the earth air tunnel system can be installed to circulate air at moderate temperature from below to maintain a comfortable temperature inside the building even when outside temperatures are extreme. As a result, reduction in energy requirement for cooling and heating the building is achieved.

Earth air tunnel is more apt in institutional campuses having a large footprint. TERI Retreat at Gual Pahari, Gurgaon, and IIT Kanpur are good examples where this technology has been successfully used.

Biomass energy

Most biomass plants use direct-fired combustion systems,i.e., they burn biomass directly to produce high pressure steam that drives a turbine generator to generate electricity. The system is more feasible and efficient in the rural areas where biomass is readily available or have plants where biomass is a by-product of the processes. For instance, Jain hills at Jalgaon, Maharashtra, meet their large portion of their electricity demand with installed biomass energy generator which feeds on effluent produced from their fruit processing factory on site.

BENEFITS AND CHALLENGES IN RE-INSTALLATION AT BUILDING LEVEL

There are several benefits of installing RE at the building level. Being sustainable, there is no risk of fuel run out. The Commonwealth Games Village in Delhi can substantiate the argument, wherein solar power for common areas and services has been installed. Even during the northern grid failure blackout, services were functioning properly in the campus. Also, the fuel is free of cost and readily available.

Gandhi Research Foundation, Jalgaon

The only drawback is that RE is region specific and its potential has to be analysed according to the climatic zone of the place where the building is located. Solar panels need large surfaces for installation, whereas wind speed needs to be analysed for assessing feasibility of wind energy.

Main advantage of RE installation is that it stances minimum impact on environment as energy generation process produces lesser or no waste, such as carbon dioxide and other chemical pollutants. The usage of RE installation has been questioned by many researchers in terms of high embodied energy of the equipment (Solar SPV cells) used for the technology. RE can also be a source of power generation in remote areas of the country where there is restricted or no grid supply, thus contributing to the economic growth of that area.

One of the reasons why RE has not picked momentum till now is the misconception that RE is expensive and difficult to install. Though the initial investment may be high, Life Cycle Assessment proves that it is economical in the long run. Also, there is a lack of awareness regarding renewable technology benefits among the consumer sector. Keeping in mind the pros of RE for environment and sustainable development, researches are being conducted globally to bring down the cost of RE technology to make it accessible to all. To encourage stakeholders, owners, and consultants to adopt RE in building, many organizations have come forward to support and promote RE installation.

ORGANIZATIONAL SUPPORT TO BOOST RE-INSTALLATION IN BUILDINGS

Ministry of New and Renewable Energy, Government of India

Dr A K Tripathi, Director, MNRE, in a presentation, stated that as the cost of power increases per unit using conventional fuels such as diesel, solar power becomes more cheaper and reliable source. MNRE has introduced many schemes to bring down the cost of installation and to promote RE installation. Given the constraints of utilizing roof areas in urban landscape, rooftop PV programme initiated by MNRE gives the flexibility of aggregating smaller rooftops to generate power in the range of 100 kW to 500 kW. The solar rooftop systems are then connected to the grid directly without battery backup, thus cutting down the initial investment cost.

ESCOs (Energy Saving Companies) model

This model is initiated by MNRE for solar hot water generation in India. In this model, the company owns the performance risk of the RE technology and provides free equivalent energy at lesser cost than conventional system to the consumer in lieu of the roof area and in some cases initial financing model. With betterment of the technology and support from policy-makers, the system can work for the benefit of the end-user and the energy company proposing a win–win equation.

Green Rating for Integrated Habitat Assessment (GRIHA)

GRIHA has given significant weightage to energy generation through renewable means along with energy optimization during construction and operation. Considering the untapped RE potential and benefits it showcases, RE installation is mandatory in all commercial projects which apply for green certification with GRIHA. AU

CASE STUDY OF A GRIHA-RATED GREEN BUILDING

Government buildings or institutional buildings with larger footprint can make most out of RE. For instance, Indira Paryavaran Bhawan, New Delhi, is planned as an energy positive building, where both the building blocks and the whole central courtyard are covered with efficient SPVs generating 930 KWp. This is an efficient design as the solar PVs keep the courtyard and building shaded in Delhi's composite climate, thereby reducing demand of air-conditioning and generating more energy than the connected load of the building (855 kW). Surplus energy is being supplied to the grid. This way the campus has minimized its energy load on the grid and is making parallel financial benefits. In words of Dr Farooq Abdullah, Hon'ble Minister for New and Renewable Energy, Government of India.

> *For centuries, the Indian tradition has worshipped the sun, the wind, the earth, and water, as sources of life, energy, and creation. Today's technology provides us with a real opportunity to transform the promise of boundless and clean energy into reality. From rooftop solar power in urban agglomerations, to decentralized and off-grid solutions in remote rural communities the opportunities in renewable power are immense.*

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GREEN ENERGY INITIATIVES IN PROTECTED AREAS: HIMACHAL PRADESH

With the installation of an SPV Power Plant at Ranser, Himachal Pradesh, it is time for a breath of fresh air. **Sarita Brara** reports on how solar power is being harnessed in this small island that will help save its forests from degradation and its rich biodiversity from dying out.

A paradise for bird watchers, Ranser is a small island of about 10 hectares in the middle of the picturesque Pong Lake or Maharana Pratap Sagar as it is popularly known, in the backdrop of the snowy Dhauladar mountain ranges in Himachal Pradesh. Hundreds of tourists, especially bird watchers, make a bee line for this picturesque sanctuary during winters to get a glimpse of some of the rare species. It takes about 40–45 minutes to reach Ranser by a motor boat from Nagrota Surian settlement. There is also a place for those wanting to spend the night in the island so that they get to see the birds in the wee hours of the morning and listen to the myriad of musical sounds of birds. As there is no power supply line for the sanctuary, a diesel-run generator of 5 Horse Power was installed six months back to provide electricity. It was creating noise and air pollution, an irritant to the visitors and more importantly affecting the ecosystem, and scaring the birds away. The diesel-run generator, which had to be ferried to the resort, was proving to be quite an expensive affair. It also required frequent repairs. It was in this scenario that a decision was taken to install a solar power plant on the island to meet the requirements of power supply to the bird sanctuary, a home to migratory birds. A SPV Power Plant was installed in the month of Oct–Nov 2013. The 10 kwp solar plants have five years of AMC back up. Today, solar power is being used to run over a dozen fans and to light up the rest house.

Another 10 kwp solar plant is to be commissioned in Kibber Wildlife Sanctuary in Spiti, the cold desert area in the state. Spread over an area of 1,400 sq. km and at a height ranging between 3,800 metre and 6,000 metre, the temperature here drops to minus 40 degrees during peak winter months. The sanctuary boasts of Snow Leopard, Himalayan Ibex, Blue Sheep, Tibetan Wolf, Wild Dog, Pica, Red Fox, Tibetan Argali, Brown Bear, Woolly Hair Marmot,

and numerous birds including Snow Pigeon and Snow Cock. The climate in this area remains dry and cold with a long spell of winter from November to March. Due to irregular power supply in Kibber, which remains snow bound during winters, a solar plant is being set up in the sanctuary. This is necessary to regularize the power supply needed for a world-class wildlife sanctuary. A state of art Snow Leopard Research and Training Centre is also being set up at this wildlife sanctuary. According to Tilak Raj Dhiman, DFO, Pine Valley National Park, an un-interrupted power supply is needed for constant radio monitoring, collaring of snow leopards (for studying their behaviour), and simultaneously feeding data to the head office at Kaza is needed. This will be possible through the electricity generated from solar plant as during winters the power supply is absent for long durations due to heavy snow fall. The equipment for the setting up of the solar power plant has already reached Kibber and the commissioning of the plant is expected this summer.

Solar street lights have also been installed in the forest areas of the state and solar lamps have been provided to the rangers.

It is not only for lighting or for running other facilities, such as fans, heaters, and computers that alternate sources of energy need to be promoted. The most important reason for promoting green energy is reducing burden on the forests. The burden on forests for fuel not only leads to their degradation, but also adversely affects the biodiversity of these protected areas. Various studies have shown that the fuel sources are depleting over the years at an alarming rate.

An assessment of the fuel resource diversity and utilization pattern of Nargu Wildlife Sanctuary of Himachal Pradesh, NW Himalaya, was carried out by Pankaj Sharma and S S Samant of the Himachal unit of the National G B Pant Institute of Himalayan Environment and Development from 2008 to 2012.

A research paper on the assessment was published in the *International Journal of Biodiversity and Conservation* stated. Among the 23 surveyed villages, about 45 species [33 trees and 12 shrubs] belonging to 23 families were used as fuel by the inhabitants. Among the surveyed villages, maximum total collection was reported from Mandra village [7,992 kg per household per year] followed by 7,524 kg in Seri, and 7,476 kg in Drun village."

This case study is enough to show the urgency to discourage the use of fuel wood especially from protected areas.

In Himachal Pradesh, over 90 per cent of the population lives in rural areas and nearly 70 per cent of heating and cooking needs are fulfilled through fuel wood in villages as most villages in the state get electricity. Himachal Pradesh is one of the major bioenergy consumers in India with an annual fuel wood consumption of 3.2 million tonnes. The reason is "as some studies have pointed out, despite well-developed kerosene and LPG distribution systems in rural areas, people are hesitant to switch over to these options due to lack of awareness and high cost.

There are 33 wildlife sanctuaries and two national parks in Himachal Pradesh covering 0.76 million hectares of land. Efforts have been going on for more than a decade to educate the communities living around the forests on the need to conserve forests and usage of alternate sources of energy. Availability of cooking gas and distribution of solar cookers at highly subsidized rates are some of the measures being taken to encourage the villagers in and around wildlife sanctuaries not to solely depend on firewood for fuel.

According to the Principal Chief Conservator of Forests (Wild Life), Dr Lalit Mohan, the focus of these initiatives on encouraging alternate sources of energy is on the areas rich in biodiversity.

Dr B S Rana, CF, Great Himalayan National Park GHNP, says that both gas connections and solar cookers were first provided to people in villages that fell within the boundaries of the National Park in 2002. Till 2008 over 1,000 gas connection and solar cookers were provided to the villagers to discourage them to use fuelwood for cooking and heating. In Majathal wildlife sanctuary, area that falls under Solan district, 130 solar cookers costing around Rs 1,150 each were distributed to reduce the burden on forests for fuel woods. However, villagers got it at subsidized rates while the BPL families had to pay just Rs 300 for the cookers. Others got it for Rs 600 rupees. LPG is being provided to the villagers in the sanctuary area so that they do not use firewood for cooking, etc. Hemant's family is among them. He says, they now cook rice, pulses, and vegetables in solar cooker. "Earlier we were totally dependent on forest wood for cooking and heating water during winters, but now this has been reduced by half. However, during winters and cloudy days, we can't use solar cookers."

While most of the villagers agree that cooking gas and solar cookers have reduced their dependence on fuel wood from forests, they admit that as most people living in these areas are poor, fire wood from forests is still an important source of energy for cooking and heating water.

Many other villagers agreeing with Hemant say that for generations people have been using free firewood from jungles and while the dependence has been reduced from 20 to 75 per cent in certain cases, still it will take some time before they switch totally to other sources of energy whether it is electricity, LPG, or solar cookers. Also, because of the low purchasing power and earning capacity of the villagers, firewood is preferred over other energy sources for which they have to pay.

Forest department and village panchayats are also making efforts to educate the villagers on how reducing dependence on forests for firewood can be beneficial for the biodiversity of the forests and decrease pollution.

The environment policy guidelines issued by the Department of Science and Technology in Himachal Pradesh calls for the popularization and expansion of the programme on the use of non-conventional energy sources, improved chullahs, solar energy systems, biogas, LPG, and Kerosene oil. It suggests that for popularization of non-conventional sources of energy, appropriate quantum of subsidy under different programmes needs to be looked into to ensure that the subsidy amount is commensurate with the gains in terms of conservation of forests, protection of environment/ecology, etc. It says that a lot can be done to exploit its non-conventional sources and technologies, such as solar passive housing, etc. The burden on forest wealth of supplying fuelwood can be reduced if available alternatives are effectively propagated among people. This will save the forests from degradation, reduce carbon emissions, and save the rich biodiversity of wildlife sanctuaries and parks. AU

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INVITING ARTICLES

AKSHAY URJA

The need to have a sustainable energy supply necessitates the exploration of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. RE can play an important role in resolving the energy crisis in urban areas to a great extent.

Today RE is an established sector with a variety of systems and devices available for meeting the energy demand of urban inhabitants, but there is a need to create mass awareness about their adoption. *Akshay Urja* is an attempt to fulfil this need through the dissemination of 20,000 copies (bilingual) in India and abroad. The magazine publishes news, articles, research papers, case studies, success stories, and write-ups on RE.

Readers are invited to send material with original photographs and statistical data. The photographs should be provided in high resolution files on a CD or through email. Akshay Urja will pay an honorarium of Rs 2,500 to the authors for each published article of 1,500 words and above. The publication material in two copies, along with a soft copy on CD/DVD/ email may be sent to:

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DELHI SUSTAINABLE DEVELOPMENT SUMMIT (DSDS) 2014

The 14th Delhi Sustainable Development Summit (DSDS) took off with a lamp-lighting ceremony in the presence of dignitaries from across the world. Dr Farooq Abdullah, Hon'ble Minister of New and Renewable Energy, Government of India, delivered the speical address at the session. He stated that the need of the hour is to work together to counter the ill-effects of humanity on the planet.

Discussions and deliberations at the event focused on the theme for the year which was *'Attaining Energy, Water, and Food Security for All'*. Discussions at the Summit addressed security of energy, water, and food as inter-related as well as independent entities. Mr Salman Khurshid emphasized that sustainable development is not possible without attaining energy, food, and water security for all and collaborative efforts amongst all stakeholders is needed for achieving this development. In fact, no global effort to live in peace together is complete without development that is sustainable by itself and that also sustains over time. He summed up by saying that conservation and preservation will come only if we stop destruction.

The session also witnessed the presentation of the 10th Sustainable Development Leadership Award, which was awarded to Mr Anand Mahindra for his contribution to education in the form of CSR.

At DSDS 2014, over 40 countries were represented by their political heads, lead thinkers, and delegates, with a total of over 1,000 delegates attending the plenary sessions and thematic tracks, over the four days of the Summit. A string of Special Events were also hosted on the side-lines of the Summit. The evening prior to the Summit (February 5, 2014) engaged leaders and eminent personalities from the world of business and politics at the High Level Corporate Dialogue themed *How will Businesses Lead India's Energy, Water and Food Security?*. The Summit engaged the captains of industry in lively discussions that will encourage action on part of the business community towards developing sustainable business practices.

Dignitaries lighting the lamp at the Inaugural Session.
L-R: **Mr Salman Khurshid**, Hon'ble Minister of External Affairs of India; **HE Mr Danny Faure**, Vice President, Seychelles; **Dr Kofi Annan**, Chairman, Kofi Annan Foundation & Former Secretary-General, United Nations; **Dr Annapurna Vancheswaran**, Director, Sustainable Development Outreach Division, The Energy and Resources Institute (TERI); **Dr Farooq Abdullah**, Hon'ble Minister of New and Renewable Energy, India; **Dr R K Pachauri**, Director-General, TERI

A session titled "Role of Renewable Energy in Enhancing Energy Security in Developing Countries" which was conducted jointly by the UK government and TERI was chaired by Mr Gyan Chandra Acharya, Under-Secretary-General and High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States. At this session Dr Pachauri highlighted that renewable energy will help marginalized people of developing countries increase economic growth and reduce imports. The panel outlined the importance of understanding the concept of energy

> IF WE WORK TOGETHER, THERE'S NO DANGER TO US. PLEASE START THINKING ABOUT OTHER NATIONS TOO.
>
> **Dr Farooq Abdullah**

> IT [SUSTAINABLE DEVELOPMENT] IS NOT MERELY ABOUT IMPROVING CONDITIONS OF LIFE; IT IS ABOUT LIFE ITSELF.
>
> **Mr Salman Khurshid**

security with specific reference to developing countries, and to expand traditional definitions of energy security to include renewables. The speakers agreed that developing countries have sufficient renewable energy resources but need better technologies to realize this potential. This requires political commitment and international cooperation to scale up efforts. They noted that there is a trade-off between energy and food security, especially when it concerns biofuels, and though efforts towards RE are being made, conventional fuels would retain their importance. There was a call for a framework to enhance deployment of RE to achieve targets, particularly among the marginalized sections of society.

The imperative for a balanced approach along with meaningful lifestyle changes among populations was emphasized upon at this session, in order to ensure that we are able to change the future course of humanity.

REGIONAL LAUNCH OF THE UNITED NATIONS 'SUSTAINABLE ENERGY FOR ALL'

Dr Kandeh K Yumkella, Secretary-General's Special Representative for Sustainable Energy for All (SE4All) and Chief Executive of the SE4All, urged countries across Asia to commit to achieving sustainable energy for all. He pointed out that 30 per cent of humanity relies on biomass for their energy needs and was committed to eliminating this dependence. He was speaking at the Asia regional launch of the 'UN Decade for Sustainable Energy for All (2014–2024)', hosted by TERI on the occasion of its annual flagship event the Delhi Sustainable Development Summit (DSDS). Also present on the occasion were Dr Shashi Tharoor, Dr R K Pachauri, and Mr Dev Sanyal. Dr Shashi Tharoor highlighted "India is deeply committed to all the three focus areas of the SE4All initiative. We have energy access as our domestic goal already. The government aims to double the country's energy capacity and it's a challenge, not just for the government alone, but the civil society and the private sector." Dr R K Pachauri expressed his solidarity with the initiative, and stressed "we need sustainable energy to be the engine and driver for making a sustainable difference." The United Nations General Assembly (UNGA) unanimously declared 2014–2024 as the Decade of Sustainable Energy for All, underscoring the importance of energy issues for sustainable development and for the elaboration of the post-2015 development agenda. In recognition of women and children, the initiative – SE4All is dedicating the first year of the decade to the Energy–Women–Children–Health nexus to raise awareness about the potential benefits modern energy services can bring to women and children.

Feature
YOUR PRODUCT!
Want to let our readers know about YOUR product?

Now, feature your renewable energy product on Akshay Urja, a bilingual magazine, widely circulated to all stakeholders of renewable energy, for a cost of Rs 40,000 only.

Send us a mail with the following details:
- Name of product
- Colour photograph
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- Technical Specifications
- Total number of products sold as of date
- Advantages of use
- Contact details of parent company
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A CONFERENCE ON ACCELERATED DEPLOYMENT OF ROOFTOP SOLAR PV SYSTEMS IN INDIA

The Energy and Resources Institute (TERI) in association with the Shakti Sustainable Energy Foundation, Ministry of New and Renewable Energy (MNRE) Chandigarh Renewal Energy Science and Technology Promotion Society, and Solar Energy Corporation of India had organized a conference titled 'Accelerated Deployment of Rooftop Solar PV Systems in India' in March 2014. The conference primarily focused on accelerated deployment of rooftop solar PV systems in India. The forum has also provided an excellent opportunity for dialogue among various stakeholders and share knowledge on technological options for promoting rooftop solar PV systems in the country. More than 100 delegates participated in this event.

The main objective for this conference was to release the Rooftop Solar Web-GIS Tool for Chandigarh. The official release of this tool (Version 1.0) is available at: http://regisindia.teriin.org/solar/Solar-WebGIS.php. For more information and accessing the Renewable Energy Geo-Spatial Gateway of India (RE-GIS India), kindly visit www.regisindia.org

Speaking on the occasion, Mr Shivraj V Patil, Governor of Punjab and Administrator, UT Chandigarh, said: "Solar energy is revolutionizing the world. Countries are investing in this sector because it is beneficial to the environment and also saves on energy costs". He urged the private sector to take a leaf from solar initiatives in China, Europe, and Japan and invest in solar devices, saying that manufacturing indigenous solar technologies by Indian companies could bring down the cost of solar products.

SOLAR
Solar Energy Corporation of India
(A Government of India Enterprise)
CREST
SHAKTI SUSTAINABLE ENERGY FOUNDATION
Conference on
nent of Rooftop Sola V Systems in India"
12 March 2014, New D
Alekhya Datta
Chinmaya Acharya
Shivraj V. Patil
Leena Srivastava

Panelists at the conference.
L-R: **Mr Chinmaya Acharya**, Shakti Sustainable Energy Foundation; **Mr Shivraj V Patil**, Governor of Punjab & Administrator, UT Chandigarh; **Dr Leena Srivastava**, Vice Chancellor, TERI University; **Mr Santosh Kumar**, Director, CREST

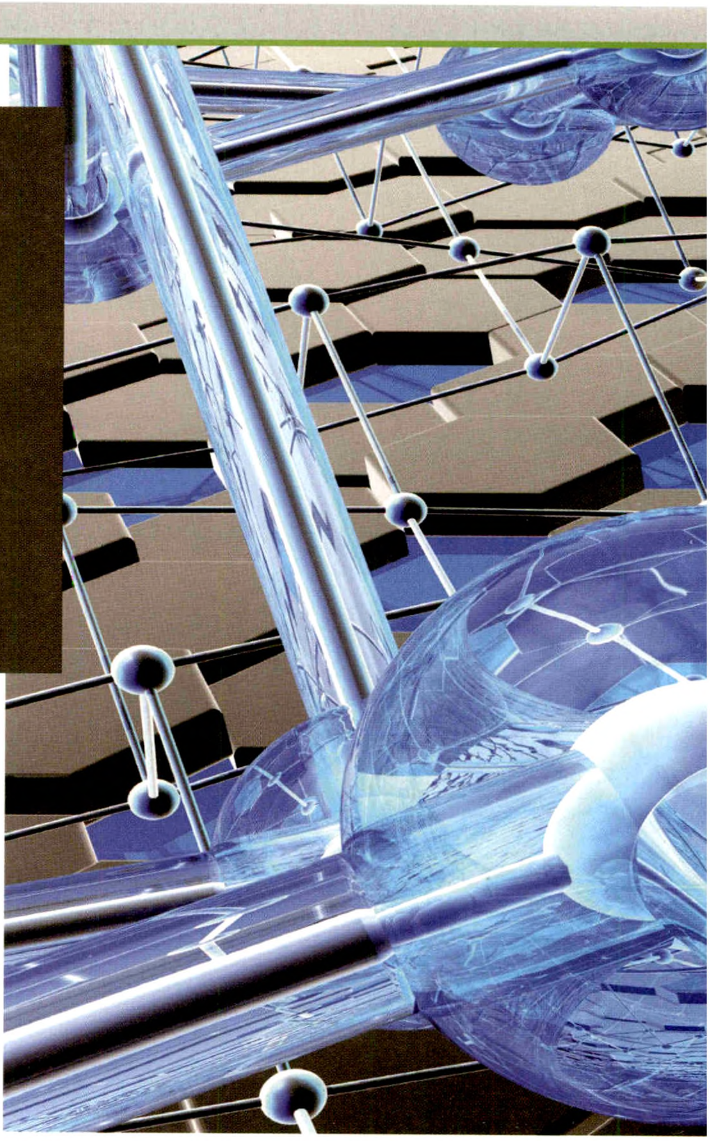
Other dignitaries at the event included Dr Leena Srivastava, Vice Chancellor, TERI University and Honorary Executive Director, TERI; Mr Chinmaya Acharya, Shakti Sustainable Energy Foundation; Dr Arun Kumar Tripathi, Director, MNRE; Mr Santosh Kumar (IFS), Director (Science and Technology), and CEO, Chandigarh Renewal Energy, Science and Technology Promotion Society; and Dr Vandana Sharma, Deputy Director General and Head, Remote Sensing and GIS Division, National Informatics Centre, Ministry of Communication and Information Technology. Distinguished panelists participated in the high-level roundtable discussion on the approach needed for accelerated deployment of rooftop solar PV systems in India.

Mr Alekhya Datta, Research Associate, TERI, presented the 'Rooftop Solar Web-GIS Tool for Chandigarh', and demonstrated the 'SPV4All' mobile application (Beta Release) during the Technical Session – I. Dr Ujjwal Bhattacharjee, Senior Fellow, and Mr Sudhakar Sundaray, Research Associate, TERI, showcased the outcomes of the white paper titled 'Accelerating Behind the Meter: Solar Energy Penetration through Market Transformation and Enabling Policies'. The conference was concluded with a Panel Discussion titled 'Accelerated Deployment of Rooftop Solar PV: Way Forward'. An 'Innovation Showcase' was also organized during this event to exhibit and demonstrate the various products available for rooftop solar PV systems in India.

Recorded Webinar on 'Rooftop Solar Web-GIS Tool' is available at http://www.youtube.com/watch?v=44zQYUtY5J4 AU

Courtesy: TERI, New Delhi

NANOELECTRONICS KEY TO ADVANCES IN RENEWABLE ENERGY/ NANOTECHNOLOGY BRIDGING THE GAP?

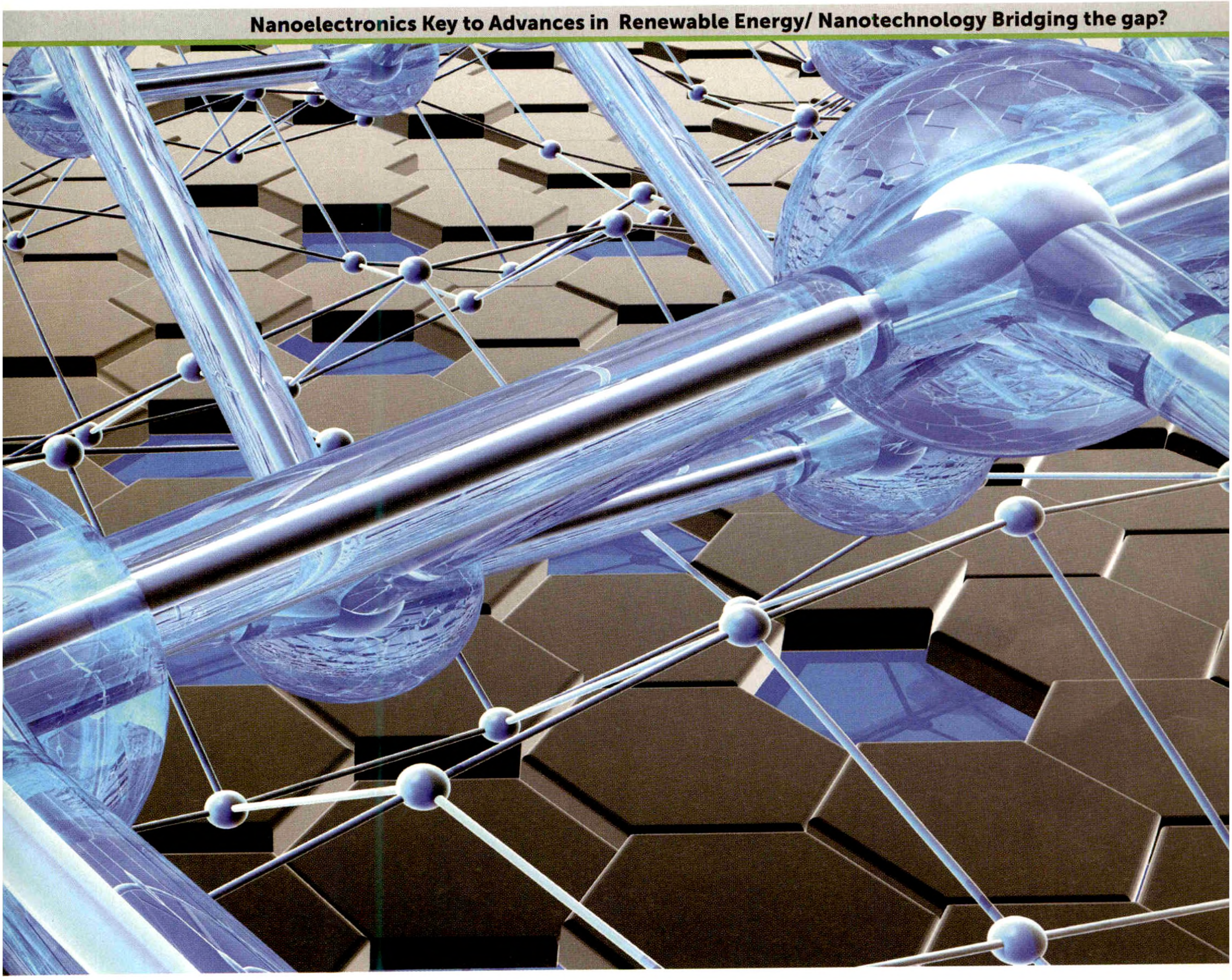


Nanoscale technology may be the mantra that will unlock the secret to major advancements that would fulfill the need for clean and renewable sources of energy. Find out more about this path-breaking discovery.

Clean power generation from renewable energy is seen as the solution to the climate impacts of the energy sector. However, there are barriers yet to be overcome to scale up energy production through renewables. Nanotechnology is the engineering of functional systems at an atomic and molecular scale. Generally, it works with materials and structures having at least one dimension sized from 1 to 100 nanometers. In addressing global energy concerns, nanotechnology has the potential to significantly slash the impact of energy production, storage, and use. While it would still take a long way to establish a sustainable energy system, scientists are looking at a further development of energy nanotechnologies. Its unique capability to fabricate new structures at, atomic scale has already produced novel materials and devices with great potential applications in a wide number of fields, such as in medicine, electronics, biomaterials and specifically, energy production.

A nanometer is one-billionth of a metre. About 100,000 nanometers amount to the same thickness as a typical sheet of paper! At that tiny scale, silicon and other materials that are used to make solar cells can perform in ways that boost the effectiveness of devices for producing energy. According to Stephen Goodnick, ASU engineering professor, "With the use of nanoparticles, made into nanostructures, we could, for instance, improve optical collection, enabling systems to trap more light for conversion into electrical power." "Using nanomaterials, we could make solar cells even thinner but still more efficient, and we could increase the capacity of energy-storage devices." Such progress will hinge on the success of science and engineering research in overcoming current high production costs and some technical challenges. But, Goodnick says he's confident, that nanotechnology advances "are going to be big factors in the future of energy". Goodnick has been awarded the German university's Hans Fischer Senior Fellowship for research at the institute.

According to the *Roadmap Report Concerning the Use of Nanomaterials in the Energy Sector* from the 6th Framework Program, a report funded by the European



Commission, nanotechnology presents the most potential in the domain of energy conversion, including solar photovoltaics, hydrogen conversion, and thermoelectric devices. The main challenges now for the application of nanomaterials in the energy sector are the improvement of efficiency, reliability, safety and lifetime, as well as the reduction of costs. To date, universities, research institutes, and even governments are paying attention to the synergy that could be established between nanotechnology and renewable energy.

In Singapore, the Institute for Bioengineering and Nanotechnology was created to work closely on the field. Recently, the institute has developed a more efficient and longer lasting fuel cell through a compound of gold, copper and platinum nanoparticles. The researchers found out that replacing the innermost part of the catalyst of the fuel cell with gold and copper alloy, while leaving just the outer layer in platinum, will deliver five times higher activity. Platinum nanoparticles are often used as catalyst in commercially available fuel cells, since platinum is the only metal that is resistant to extreme acidic condition inside such a cell. The prevalent use of fuel cells has been deterred by the high cost of platinum and its low stability, said the institute, and the new advanced fuel cell material could help overcome these barriers, providing a less expensive material and much greater stability.

In 2011, the US President Barack Obama launched the Advanced Manufacturing Partnership, a national effort by the industry, universities, and the federal government that provides more than $500 million in investments in emerging technologies such as information technology, biotechnology, and nanotechnology.

To conclude, nanoscale technology looks promising as a major contributor to advancements needed to fulfill the potential of emerging sources of clean, renewable energy. Progress in the comparatively new area of nanoelectronics in particular could be the basis for new manufacturing processes and devices to make renewable energy systems and technologies more efficient and cost-effective. AU

Source: http://www.sciencedaily.com

PIZZA BOX SOLAR OVEN

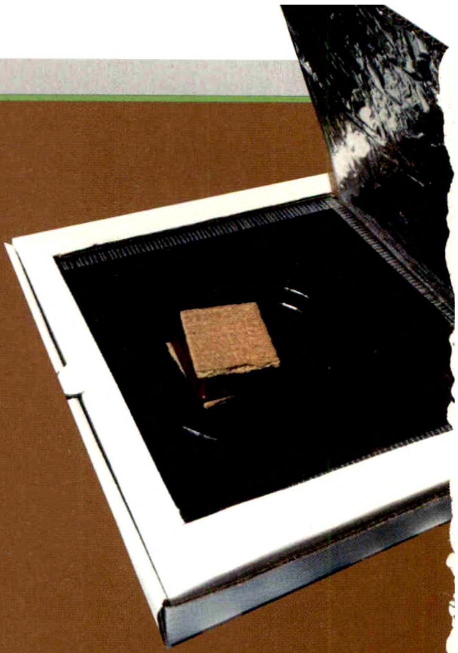
Bring the goodness of campfire to your very backyard now! This easy DIY solar power project will help your child learn the importance of using renewable sources of energy in their daily lives.

MATERIALS NEEDED

- Large pizza box
- Pencil and ruler
- Craft knife
- Aluminum foil
- Scissors
- Glue stick
- Black construction paper
- Clear packing tape
- Clear plastic
- Biscuits and chocolate bars
- Stick or dowel

HOW TO ASSEMBLE

- First, draw a square on the pizza box top — one inch smaller than the outside edge, all the way around.
- Next, use the craft knife to cut along the drawn square edges on three sides. Fold the cardboard along the uncut line to form a flap.
- Glue aluminum foil with the shiny side facing the outside to the bottom of the flap. Try to keep the foil as wrinkle-free as possible.
- Once this is in place, glue another piece of foil to the inside-bottom of the pizza box. Tape black construction paper on top of the foil.
- Next, take the clear plastic and tape it to the underside of the box lid to seal the opening created by the flap. Try to create an airtight seal with the plastic, as this will trap the most heat.
- Finally, place your Solar Oven in direct sunlight outdoors with the flap open towards the sun. You are now ready to cook!



HOW TO MAKE SOME GOODIES

- Place your biscuits on the black construction paper; top with a piece of chocolate. Close the box, and use a stick to prop the flap open to reflect sunlight into the box.
- The gooey results will occur in about an hour's time depending on how hot it is.
- Be careful, as the foil may be very hot! Temperatures for the oven after 1 hour time can exceed 275 degrees!

Rising fuel prices, increased congestion, and loads of pollution... But how can I not use my car? Oh! What do I do?

Use of public transport is indeed the best solution!!!

Illustration: Vijay Nipan

JAIN JYOT SOLAR WIND HYBRID SYSTEM

This hybrid system offers a solar and wind hybrid Street Light Systems as a Green energy solution. The power source of this hybrid street lighting system is natural wind and solar radiation. This hybrid system is more cost-effective and reliable in high wind zones. The whole system can also be used for power generation at private homes but its capacity will depend on the load that it needs to bear. The hybrid lighting system is a self-sufficient and standalone solution that requires neither the construction of a costly main grid electricity supply infrastructure nor the burden of their associated operating expenses. The systems are ideal solutions for many applications in cities and rural areas, providing lighting to enhance security and safety.

Power generation is dependent on the availability of both wind and solar radiation.

FEATURES

- System output: DC and AC current simultaneously, and a wide voltage range
- Automatic system operation
- The wind turbine can be from 300 W to 4,200 W in the wind velocity range of 3.1 m/sec to 15 m/sec
- The system consists of Luminaries, Lighting Pole from 5 m to 30 m height, Deep Cycle Tubular Lead Acid Battery, Solar Panels, etc.
- Lighting fixtures are available in different types and lighting bulb in different Lumen flux

QUALITY ASSURANCE

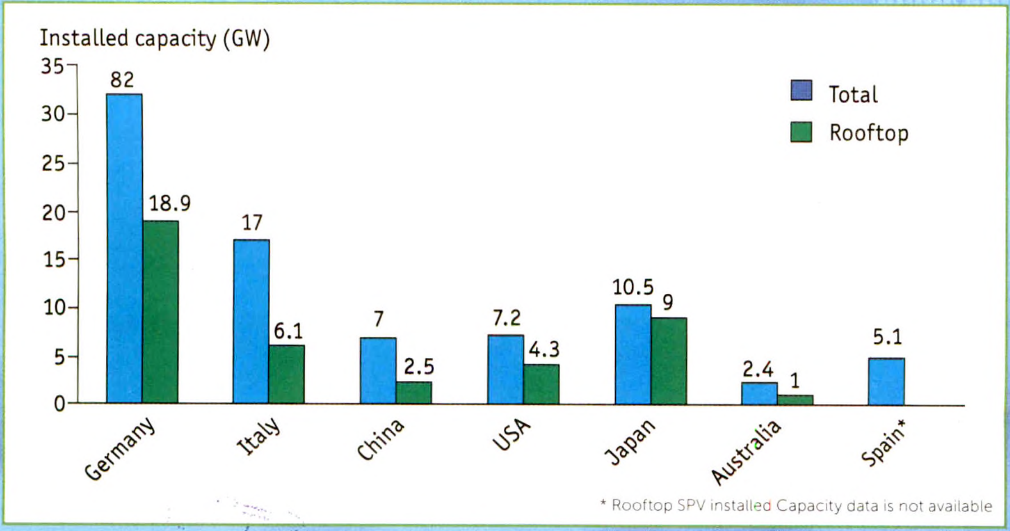
- A long life span of system components:
  - » Wind turbine with 15 years
  - » Solar module with 25 years

BENEFITS

- Ecologically sound
- Clean renewable energy
- Reduction of carbon footprint
- Low maintenance
- Enchances neighbourhood security
- Cost-effective long-term lighting solution

Source: http://www.jains.com/Solar/jain%20jyot/jain%20jyot%20solar%20wind%20hybrid%20system.htm

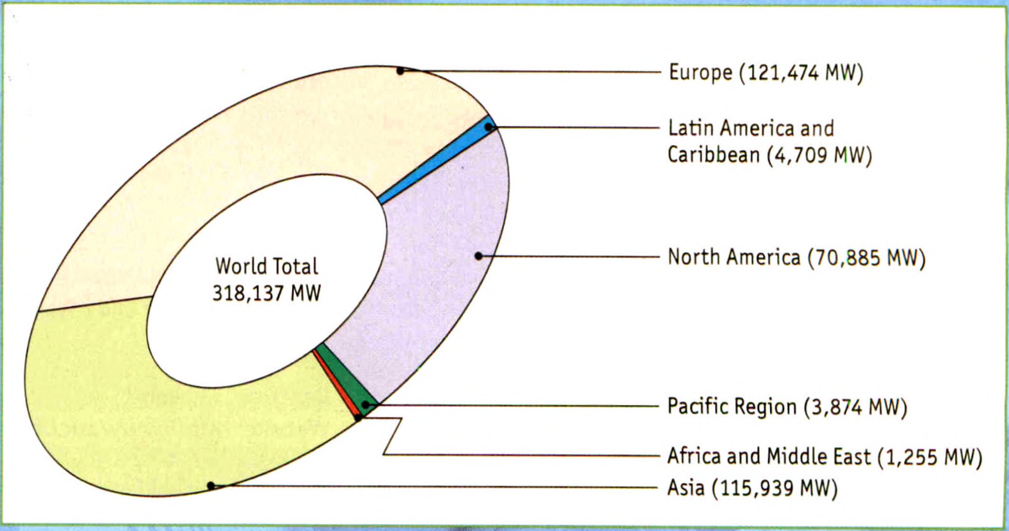
RENEWABLE ENERGY AT A GLANCE: GLOBAL SCENARIO



* Rooftop SPV installed Capacity data is not available

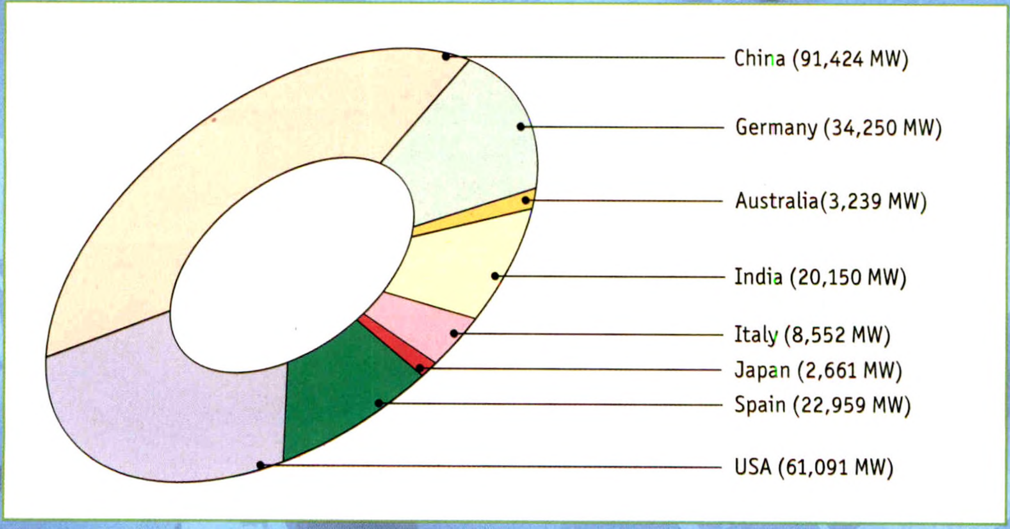
SPV PLANTS, ROOFTOP AND INSTALLED CAPACITY TILL MARCH 2013

Source: Complied by TERI



WIND POWER INSTALLED CAPCITY (MW) TILL END OF 2013 (REGION-WISE)

Source: Global Wind Energty Council (Gwec), 2013. Global Wind Statistics 2013.



WIND POWER INSTALLED CAPACITY (MW) TILL END OF 2013 (COUNTRY-WISE)

Source: Global Wind Energty Council (Gwec), 2013. Global Wind Statistics 2013.

Suraj Ek Roop Anek

Solar Photovoltaic Technology

ALCUTTA
ENTRAL
RY

सौर प्रकाशवोल्टीय प्रौद्योगिकी

श्रृंखला / समानान्तर संयोजन में सौर पीवी मॉड्यूल (लों), इंटरफेस इलेक्ट्रॉनिक्स, यांत्रिक सहायता विन्यास, केबल, स्विच आदि के मिश्रण से सौर प्रकाशवोल्टीय प्रणाली (एसपीवी) का निर्माण होता है। भंडारण बैटरियों का प्रयोग सूर्य की रोशनी के उपलब्ध न होने के समय उपयोग के लिए दिन के समय उत्पादित सौर ऊर्जा का भंडारण करने के लिए किया जाता है। एसपीवी प्रणाली का उपयोग रोशनी, जल पंपिंग और बैटरी चार्ज करने के साथ–साथ ग्रिड को बिजली की आपूर्ति करने आदि के लिए किया जा सकता है।

एसपीवी प्रणालियों का उपयोग बैटरी भंडारण सुविधा के साथ या इसके बिना "स्टैंड–अलोन प्रणाली" अथवा "ऑफ–ग्रिड प्रणाली" के रूप में किया जा सकता है। "ग्रिड–संबद्ध प्रणाली" के लिए बैटरी भंडारण की आवश्यकता नहीं होती। कुछ लोकप्रिय एसपीवी प्रणालियां हैं : सौर लालटेन, सौर घरेलू रोशनी प्रणाली, सौर सड़क रोशनी प्रणाली, एसपीवी जल पंपन प्रणाली, स्टैंड अलोन एसपीवी विद्युत संयंत्र।

Solar Photovoltaic Technology

A combination of solar PV module(s) in series/ parallel combination, interface electronics, mechanical support structure, cable, switches, etc. constitutes a solar photovoltaic (SPV) system. Storage batteries are used to store solar energy produced during the day for use in non-sunshine hours. A SPV system can be used to provide electricity for lighting, water pumping, and battery charging as well as for feeding power to the grid etc.

The SPV systems can be used as a "Stand-alone System" or "Off-grid systems" with or without battery storage facility. A "Grid Connected System" does not require battery storage. Some of the popular SPV Systems are Solar Lanterns, Solar Home lighting Systems, Solar Street Lighting Systems, SPV water pumping systems, Stand-alone SPV Power Plants, etc.

नवीन और नवीकरणीय ऊर्जा मंत्रालय **Ministry of New and Renewable Energy**

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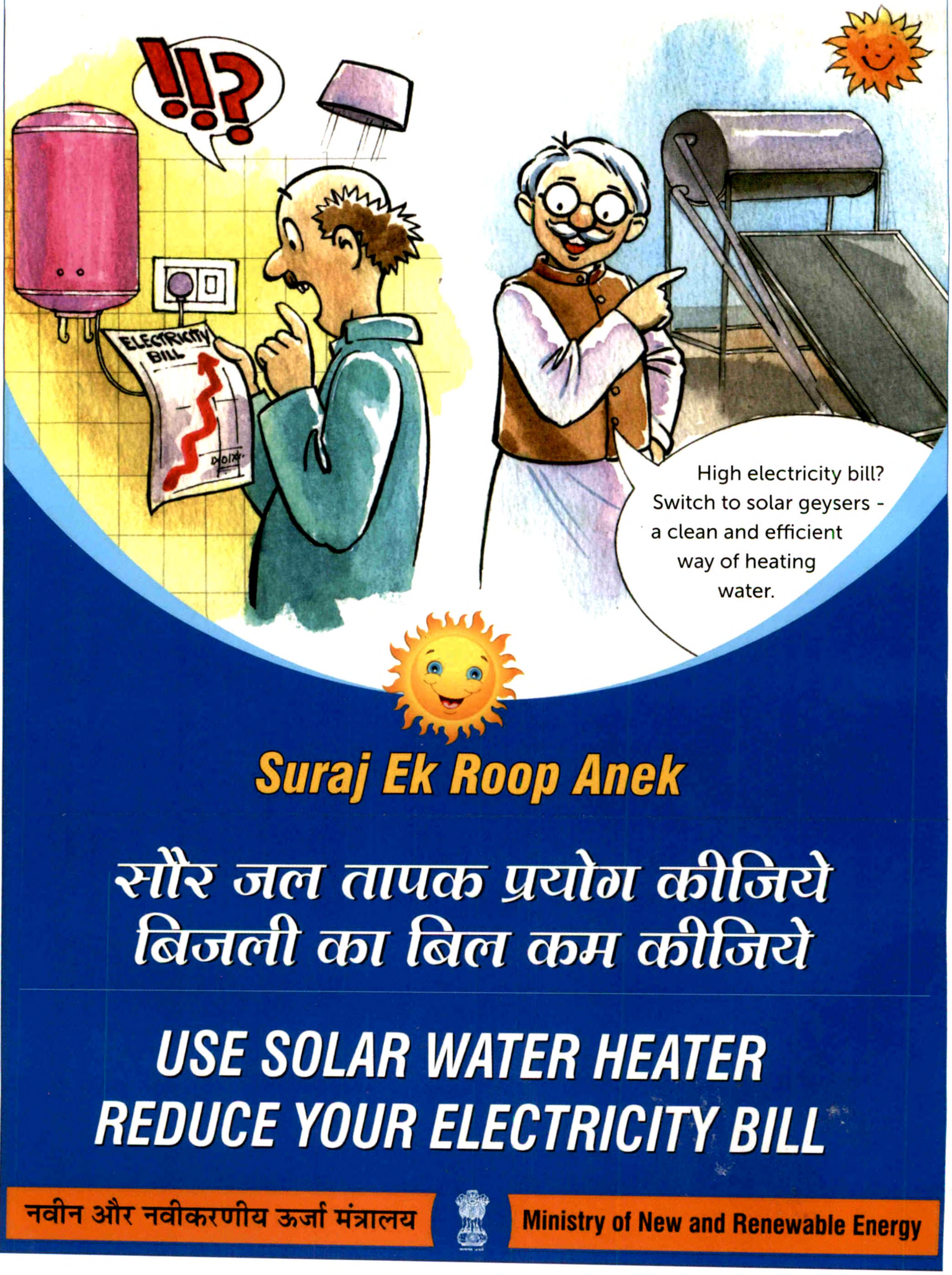
!!?
ELECTRICITY BILL
High electricity bill? Switch to solar geysers - a clean and efficient way of heating water.

Suraj Ek Roop Anek

सौर जल तापक प्रयोग कीजिये
बिजली का बिल कम कीजिये

USE SOLAR WATER HEATER
REDUCE YOUR ELECTRICITY BILL

नवीन और नवीकरणीय ऊर्जा मंत्रालय **Ministry of New and Renewable Energy**